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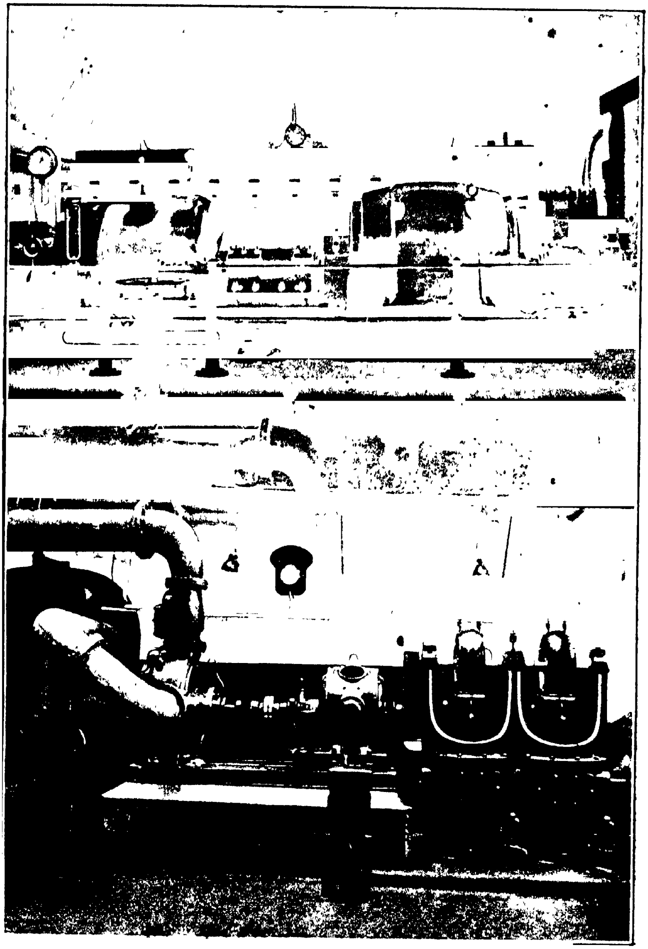

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JUTE AND JUTE SPINNING

ART I

PRODUCTION OF FIBRE

BATCHING AND CARDING

BY

THOMAS WOODHOUSE

HEAD OF THE WEAVING AND DESIGNING DEPARTMENT, DUNDEE TECHNICAL COLLEGE AND SCHOOL OF ART, FORMERLY MANAGER, MESSRS WALTON & CO., LINEN MANUFACTURERS, BLEACHERS AND FINISHERS, KNARESBOROUGH, HONOURS MEDALLIST OF THE CITY AND GUILDS OF LONDON TECHNICAL INSTITUTE IN WOOL AND WORSTED WEAVING AND IN LINEN WEAVING

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THIS WORK

IS DEDICATED TO

WILLIAM HENDERSON, ESQ., C.B., D.L., J.P.

OF WEST PARK, DUNDEE

IN APPRECIATION OF HIS UNTIRING EFFORTS

ON BEHALF OF

TECHNICAL EDUCATION

PREFACE

The average annual crop of jute fibre amounts to about 2,000,000 tons, and since practically the whole of this is spun into yarns of various kinds, it is clear that the jute-spinning industry is an extensive one. Great extensions of machinery and mills are in progress, and these will still further increase the importance of the subject; hence, no apology is necessary for the introduction of the present work, especially when the literature on the subject is not very extensive.

Most of the material included in this work appeared originally in serial form in the *Textile Manufacturer;* what has been added since is for the purpose of bringing the subject up to date, and the first part of the work is now issued to the trade, and to those otherwise interested in the development of the industry.

Since the book has been written from a practical standpoint, and all the photographs and drawings prepared specially by the Authors to illustrate the various phases of the subject, it is hoped that the production will prove useful as a guide and help to mill managers, foremen and students.

Although most of the illustrations have been made from actual machines in work, the Authors are indebted for prints and other particulars to the following Firms: Messrs. Fairbairn, Lawson, Combe-Barbour, Ltd., Leeds and Belfast; Messrs. Charles Parker, Sons & Co., Dundee; Messrs. Urquhart, Lindsay & Co., Ltd., Dundee; and Messrs. Douglas Fraser & Sons, Ltd, Arbroath, as well as to Messrs. James Scott & Sons and to Messrs. James Carmichael & Sons for permission to use illustrations relating to motive power.

The appreciation and thanks of the Authors for the kindness shown by the Principals of these Firms, as well as that of private individuals, are hereby recorded.

THOMAS WOODHOUSE.
PETER KILGOUR.

Dundee,
May 1920

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JUTE AND JUTE SPINNING

CHAPTER I

BOTANICAL DESCRIPTION AND SOURCES OF THE PLANT

COMPARED with the industries of cotton, wool, and flax, the jute industry certainly occupies a subordinate position in the textile world; but, nevertheless, it is of extreme importance, and from a mechanical point of view there is perhaps no branch of this industry which is more interesting and at the same time more complicated than that which embraces the various processes which lead up to and include the operation of spinning. A description of any process of textile manufacture is invariably more satisfactory when some idea of the origin, growth, and source of the fibre used is described, and for this reason we shall devote the first two chapters of this work to the cultivation and growth of the plants, to the harvesting of the stems, and to the necessary and important treatment which these stems have to undergo in order that they may assume the desired condition for the removal of the fibrous layers to facilitate the preparation of the fibre which is obtained from them, and to some remarks which bear upon the methods of dealing with the fibre before it ultimately reaches the first department in the spinning mill.

The commercial jute fibre, or rather that which is invariably used in the textile trade, is obtained from two species of plants belonging to the order *Tiliaceæ*, and these two are closely allied to the order *Malvaceæ*, from a variety of which the cotton fibre is obtained. These two species of jute plants are known respectively as *Corchorus capsularis* and *Corchorus olitorius*, the respective fruits of which, as their names imply, are capsules and pods. Both

are annual plants which grow to a height of from 5 to 10 ft., although in exceptional circumstances they may rise to a height of 15 ft. or more. In general the fibre which is supplied for the ordinary processes of jute spinning and for the general types of jute fabrics varies in length from 4 to 10 ft. The main stem of the plant is round and smooth, its diameter is about half an inch, and there is

FIG. 1.
By permission of Messrs. Cassell & Co., Ltd., London.

a tendency for branches to shoot out if sufficient space is left between the various plants during their growth. This inclination for branching is naturally encouraged when the plant is grown for seed alone, but if the object in view is for fibre only, which is almost invariably the case, less space is allowed between the plants. The leaves are 4 to 5 in. long, and about $1\frac{1}{2}$ in. broad, while the flowers are small and of a whitish-yellow tint—the deepest colour being near the top of the plant.

Figs. 1 and 2 represent the general features of the two varieties, both being views of the top branches of the plants. In Fig. 1 the capsule fruit of the variety *Corchorus capsularis* is clearly seen in the left-hand bottom corner, while the fruit pod of the *Corchorus olitorius* is equally clear at 4 in Fig. 2. In both figures the general appearance of the leaves and flowers appears to advantage, while

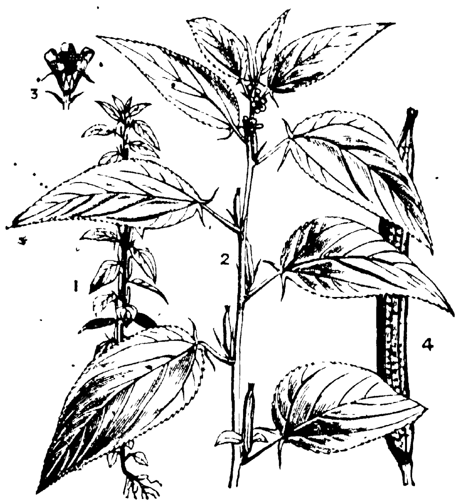

FIG. 2.
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the photographical reproduction in Fig. 3 shows in detail the various parts of one of the leaves of the variety *Corchorus olitorius.* Fig. 4 is a drawing from one of the plants; it represents a forked stem of the *Corchorus olitorius,* from each branch of which one or more pods appear. Part A shows the appearance of the pod after the seeds are disseminated; in this particular pod there were nearly ninety seeds. Near the bottom of the stem a portion of the bark has been stripped and bent back at B; the fibres are located in this part of the plant.

The botanical description of the two species will perhaps be best described by quoting from J. Forbes Royle's work on *The Fibrous Plants of India* :—

"*Corchorus olitorius*, Pot-herb, or Jews' Mallow, as seen in the Mediterranean region, is a herbaceous annual plant, only a foot or

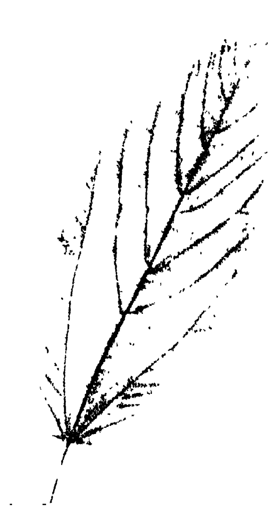

FIG. 3.

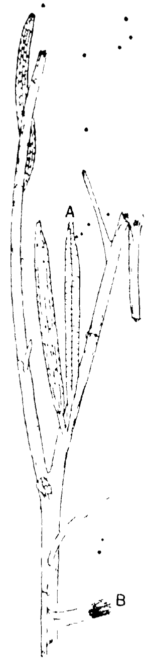

FIG. 4.

two, but in India of several feet in height, and erect in habit. The stem is smooth, cylindrical, and more or less branched. The leaves are of a lively green colour and smooth, alternate, on foot-stalks, oval or ovo-lanceolate in shape, with the margin dentate, and with the two lower dentilures terminated by a slender filament (see Fig. 3). The stipules are simple, awl-shaped, and reddish-

coloured at the base. The peduncles or flower stalks are one- to two-flowered. The flowers are small, having the calyx consisting of five pieces or sepals, and the corolla of five yellow petals. Stamens numerous. Torus cup-shaped, with glands at the base of the petals. Ovary solitary, ripening into a long, nearly cylindrical pod, ten-ribbed, six to eight times longer than it is broad, five-celled, and formed of five valves, with five terminal points. Seeds numerous, with nearly perfect transverse partitions between them."

This is called "Patta" in Sanscrit, and "Pat" in Bengalee, flowers in the rainy season and fructifies in October and November. Cloth made of it is called "Tat"; the fibre, "Jute." It is supposed to be the plant alluded to in Job xxx. 4, "who cut up mallows by the bushes."

"*Corchorus capsularis*, or 'Capsular corchorus,' is also an annual, with a straight, smooth, and cylindrical, afterwards branched, stem, from four and five to eight and ten feet in height. The leaves have long footstalks, and are oval, acuminate, thin, and of a light green; serrated at their margins, with the two lower serratures terminating in narrow filaments. The flowers are small, yellow, and like those of the other species in the number of their parts. The capsules are short and globose, wrinkled, and muricated, with five cells, and composed of five valves; seeds few in each cell, and without transverse partitions. It flowers in the rainy season, and the fruit is ripe in September and October."

This is the "Ghi-nalita pat" of the Bengalese, and its fibre is sometimes called "Nalta Jute." It is called "isbund" in North-West India. It has been called "Chinese Hemp" (*Ramitsjina*) by the Malays, and its fibre "China pat" by Roxburgh. The kind called "Teetah pat" is said to be a variety of this species.

Corchorus capsularis is cultivated in the Northern districts, whereas *Corchorus olitorius* is cultivated in the Hooghly district, the 24 Parganas, and the Sundarbans. The chief districts in which jute is grown are illustrated by numbers in Fig. 5. It will be seen from this figure, and from the names of the districts in the following table, that the area under jute cultivation extends from the Bay of Bengal right up to

the hills near the base of the Himalaya mountains, and from Champaran and Orissa on the west to Lakhimpur and Assam on the east. Approximately one-tenth of the arable land in this area, including practically one-third of that in Mymensingh, is cultivated annually for the production of jute fibre. Comparatively small quantities of other fibrous plants are grown in the same districts. It is, of course, understood that some scheme of rotation of crops is followed; rape, mustard, paddy, potatoes, peas, and similar substances being sown in rotation.

The number of bales under cultivation, the names and numbers of the districts, the number of acres under cultivation, and the yield of marketable fibre in bales of 400 lb. each, appear in the following tables:—

EASTERN BENGAL AND ASSAM

No in Map.	Name of District	1911.			1912.		
		Acres	Bales	% Out-turn	Acres.	Bales.	% Out-turn
1	Dacca	186,000	425,000	76	188,000	535,800	95
2	Mymensingh	758,000	2,137,000	94	756,000	2,155,000	95
3	Faridpur	139,500	313,900	75	150,000	427,500	95
4	Backarganj	29,000	78,300	90	29,000	82,000	95
5	Chittagong	300	900	97	300	855	95
6	Tipperah	275,000	783,700	95	268,000	763,800	95
7	Noakhali	30,800	87,800	95	26,000	74,100	95
8	Rajshahi	78,700	120,400	51	80,900	218,430	90
9	Dinajpur	116,800	350,400	100	116,800	315,360	90
10	Jalpaiguri	94,800	227,500	80	94,800	241,740	85
11	Rangpur	299,600	817,900	91	290,000	783,000	90
12	Bogra	130,000	292,500	75	130,000	312,000	80
13	Pabna	201,500	604,500	100	220,000	693,000	105
14	Maldah	30,000	63,000	70	38,000	114,000	100
15	Cachar	400	1,100	95	320	864	90
16	Sylhet	42,000	100,800	80	36,000	64,800	60
17	Goalpara	37,000	111,000	100	46,000	124,200	90
18	Kamrup	5,100	12,900	84	5,800	15,312	88
19	Darrang	1,000	2,400	80	1,300	5,040	93·3
20	Nowgong	500	1,500	100	800	2,400	100
21	Sibsagar	200	400	70	200	480	80
22	Lakhimpur	100	300	100	127	381	100
23	Garo Hills	4,400	9,200	70	4,600	12,420	90
—	—	2,461,300	6,543,400	—	2,482,947	6,943,082	—

BENGAL

No. in Map	Name of District	1911 Acres	1911 Bales	1911 % Out turn	1912 Acres	1912 Bales	1912 % Out-turn
24	Burdwan .	13,500	38,500	95	15,000	17,250	105
25	Midnapur .	7,000	16,800	80	11,000	26,400	80
26	Hooghly .	48,100	110,900	81	60,000	198,000	110
27	Howrah .	24,000	46,800	65	25,000	82,500	110
28	24 Parganas .	85,000	220,500	90	89,300	294,300	110
29	Nadiga .	47,400	125,100	88	91,000	259,350	95
30	Murshidabad .	27,700	62,300	75	40,000	114,000	95
31	Jessore .	93,000	251,100	90	165,000	544,500	110
32	Khulna .	16,800	47,000	95	38,100	120,015	105
33	Champaran .	362	900	79	900	2,295	85
34	Muzaffarpur .	2,000	6,000	100	1,400	4,200	100
35	Bhagalpur .	1,260	3,000	103	3,144	10,092	107
36	Purneah .	240,000	662,400	92	270,000	708,750	87·5
37	Darjeeling .	4,500	8,900	66	5,000	10,500	70
38	Santal Parganas .	1,000	1,200	40	7,500	22,950	102
39	Cuttack .	11,300	29,200	86	12,000	34,020	97
40	Balasore .	2,200	2,000	30	3,400	9,690	95
41	Cooch-Behar	20,000	42,000	70	32,750	88,425	90
---	—	645,122	1,691,400	—	870,494	2,578,197	—

Year.	Total Number of Acres	Total Number of Bales	Average % Crop
1911	3,106,422	8,234,800	88⅓
1912	3,353,441	9,521,279	94⅔

The final forecasts from the years mentioned above to 1919–20 are as under :—

Year	Acres	Bales	Approximate % Out turn per Acre
1913–14	3,169,000	8,746,440	92
1914–15	3,358,737	10,529,640	104½
1915–16	2,377,316	7,429,112	104
1916–17	2,686,000	8,266,266	102⅔
1917–18	2,730,000	8,904,364	108⅔
1918–19	2,500,382	8,501,258	113⅓
1919–20	2,821,000	8,636,200	102

The above figures were supplied by Messrs. J. J. Barrie & Co., Dundee. It will be noticed that the percentages are sometimes

stated above 100. This happens when the yield of fibre exceeds three bales per acre.

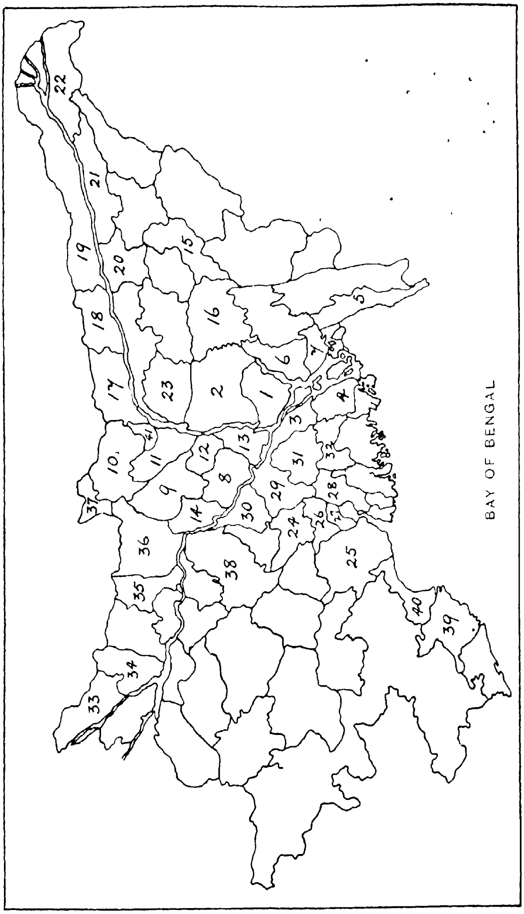

FIG. 5.

Although there is a considerable number of districts in which jute is grown, it is almost essential for commercial reasons that the

various districts should be grouped so that all may be included in a few well-defined divisions. For several years practically the whole of the jute crop was placed under four heads—viz., Naraingunge, Serajgunge, Daisee, and Dowrah. According to N. C. Chaudhury, the commercial divisions of the jute tracts are as follows:—

1. Naraingunje,
2. Serajgunje,
3. Uttarya or Northern,
4. Dowrah,
5. Daisee.

1. "Naraingunje" jute is grown on the tracts of lands which are supplied with water from the old Bramhaputra river. There is no other jute tract in Bengal where water is so clear as that of the old Bramhaputra. The colour of the jute of this tract is the best in the market. Most parts of this tract are liable to submersion by floods when the crop is still on the fields. This standing water is responsible for the "rooty" and "mossy" fibres of this tract. High lands of this tract yield fibres of exceptionally good quality. About 30 per cent. of this tract is "hessian" warp. Naraingunje and Chandpur are the principal markets in this tract, which is under the jurisdiction of Mymensingh, Dacca, and Tipperah districts.

2. "Serajgunje" jute is obtained from the tract of lands which are fed by the new Bramhaputra or Jamuna river. The water of this river is nearly equal to that of the old Bramhaputra in point of cleanliness. The principal market of this tract is Serajgunje, which is supplied with jute from the western part of Mymensingh, and from Pabna, Bogra, Cooch-Behar, Rangpur, and Goalpara. About 30 per cent. of the jute of this tract falls under "hessian."

3. "Uttarya" or "Northern" jute is grown in the tract of high lands which are principally watered by the tributary rivers of the Bramhaputra. Only a limited part of this tract receives a direct supply of water from the rivers. Jute of this tract is therefore steeped and washed mainly in ditch-water, and as the same water is used for successive steepings, it becomes more or less coloured owing to decayed vegetable matter as the operation is continued. The colour of the jute of this tract is therefore inferior. Thirty per cent. of this jute comes under "hessian." Huldibari, Domar, Kissengunj, Kasba, and Forbeshgunj are the principal

marts in this tract, which includes the districts of Rajshahi, Bogra, Rangpur, Jalpaiguri, Dinajpur, Maldah, and Purneah.

4. "Dowrah" jute is grown on the lands which are swamped by the branches of the river Ganges, containing muddy water. This muddy water imparts a grey colour to the fibre of this tract. The "Dowrah" jute is very strong, but harsh. It is used principally for sackings and cordage. Madaripur, Berhamgunj, and Angari, in the district of Faridpur, are the chief markets in this tract.

5. "Daisee" jute belongs to the species *Corchorus olitorius*. It is grown in the high lands in the neighbourhood of Calcutta. The jute of this tract is steeped in the ditch-water supplied by the rains or the rivers Bhagirathi and Damoodar, also Roopnarain, which contains muddy water during the rains. Owing to this quality of the water, and some objectionable method of steeping, the jute of this tract is more or less black in colour. This jute is used principally for bagging and for yarns which are to be dyed a dark colour. Badyabati, in Hooghly, and Belgatchia, in the 24 Parganas, are the principal markets.

This classification is naturally subject to slight deviations, and while Naraingunge, Serajgunge, Daisee, and Dowrah fibres are still household words in the trade, it is not unusual to find included in these divisions the names of Dacca, Tossa, Chittagong, and Bimlipitam. The latter, although used as, and for, a substitute of jute, is obtained from a plant known botanically by the name *Hibiscus cannabinus*, and may therefore be considered as a kind of hemp. It is largely cultivated in many parts of India, and is used for various purposes. The fruit, when ripe, is used as a vegetable, and the fibre is separated from the stalk in practically the same way as the ordinary jute fibre (see p. 22, Chapter II). The fibre of Bimlipitam jute, or *Mesthapat*, as it is termed in Bengal, is similar to some of the other jute substitutes, and it is now baled and exported as a separate grade—hence the inclusion of this name in the divisions.

The divisions are made up with regard to the particular properties and value of the fibres for commercial purposes, and the general characteristic features by means of which such classification is determined are as follows:—

NARAINGUNGE: Strong fibre; reddish cast at fibre ends, but a

creamy colour in most parts; red roots; suitable for first-class yarns, and particularly for warp which requires to be very strong.

SERAJGUNGE: Moderate strength, soft fibre, light colour, white to bluish grey; occasionally black roots, but usually free from dark-red coloured roots in the better classes; easily bleached on account of its natural light shade, suitable for first-class weft yarns.

DAISEE: Moderate strength, soft silky fibre, dark colour, light red to slate and dark grey, suitable for mixing with other qualities, or for use alone where colour is unimportant.

DOWRAH: Medium strength; hard and brittle fibre, generally darkish colour; suitable for common thick wefts or ropes; very rooty and barky fibre.

BIMLIPITAM OR MESTHA: Fair to poor colour, short to fair length of fibre, but harsh, lacks the spinning properties which are possessed by the ordinary grades of jute.

TOSSA: Fibre similar to the finest Daisee, but much cleaner and stronger, fine lustre and quality in the finer grades, and suitable for fine yarns.

DACCA AND CHITTAGONG: These fibres are similar to Naraingunge qualities.

The characteristics of the same or similar kind of fibre vary according to the particular soil in which the plants have been grown, and will also vary slightly with the climate. Although the above remarks represent generally the chief features of each class, they cannot be expected to be absolutely reliable in every case. The remarks as to strength, general colour, and suitability for particular kinds of yarn may be considered fairly accurate, but more details of some of these properties will be discussed in connection with the actual processes of preparing and spinning. Considered generally, the main features by which the quality of jute is estimated are: Length, strength, lustre, fineness, softness, uniformity in colour, absence of roots, cleanness of fibre, and spinning properties, but for particular classes of yarn one or more of these features may be unimportant. These points will be considered as occasion arises.

Both species of jute plants have early and late varieties. The early varieties yield the finest fibre, but the late varieties give the heaviest yield of fibre. It is customary to cultivate the early varieties on those lands which are subject to early floods; by this

arrangement the plants almost invariably reach a height of from two to three feet before the time of the floods, and hence they are sufficiently strong to withstand the action of the water. In many districts both early and late varieties are cultivated—a process which enables harvesting to be performed at different periods. In all cases it is advisable, if not imperative, to resort to interchange of seed, for the greatest success results from this method. Jute plants are often grown in Assam for the sake of the seed, and this seed is then imported in large quantities to Mymensingh and other large jute-growing centres.

Although attempts have been made to grow jute in various parts of the tropics, notably in the Nile Valley, Nigeria, Sierra Leone, and in many other parts of Africa, in Java and in French Indo-China, India is the only country in which the cultivation of jute has been a real commercial success; and even in India there are several districts which are unsuitable for the growth of the plants. The necessary and sufficient conditions for the successful cultivation and growth of jute are:—

1. A high temperature with a minimum of about 80° F. during the period of growth.
2. A suitable soil.
3. Sufficient rainfall.
4. Distribution of rainfall over period of growth.
5. An ample supply of water for retting the plants and for washing the stripped fibre.
6. A suitable and efficient supply of labour to handle the crop at the proper time—the operatives to be experienced and to have a good knowledge of the best methods of retting, stripping, and cleaning.
7. Facilities for placing the fibre on the market.

The hot moist climate of Bengal and Western Assam is evidently an ideal one for the growing of jute, although even in these famous jute-growing districts the various kinds of soil produce plants the fibres of which vary in quality as well as in quantity. The plants may be grown successfully in three different kinds of soil:—

1. The rich sandy loams of the hill tracts or high lands, termed "sunna lands" by the natives. If proper care is exercised

in the cultivation of the plants and in the preparation of the fibre, these lands produce the finest qualities of jute with respect to both strength and colour.

2. The chur or char lands—*i. e.*, alluvial soils which are situated in the neighbourhood of the river tracts, and which are inundated during certain parts of the season by the overflowing of the rivers; the ground thus receives a new top-dressing annually, and on this account it requires little or no manure. The bulk of the jute crop is cultivated on these soils.
3. The marshes or low-lying lands on the sides and in the deltas of the rivers; these are often termed sali or salee lands. The Sundarbans near to and on the mouths of the Ganges possess a soil which, with careful farming, is suitable for the production of a large quantity of fibre of the commoner grades. During the rainy season large tracts of these lands are practically under water.

The proper distribution of the rainfall, especially during the early periods of growth, is essential to success in the growing of jute. Alternate showers and sunshine are necessary during the early stages, but a greater quantity of water is desirable from the time the plants are 1½ to 2 ft. high until they reach maturity.

An abundant supply of water for the operations of retting and washing is just as essential for the successful treatment of the plants as ideal atmospheric conditions are for the growth of the plants. The weight of the plant crop—or green crop, as it is usually called—is between 300 and 400 maunds per acre (82$\frac{2}{7}$ lb. per maund); hence a sufficient supply of the proper kind of water near the jute fields is an absolute necessity. Moreover, a sufficient number of qualified operatives must be obtainable in order to deal immediately, not only with the green crop, but also with the plants in the subsequent operations at the proper time; when these conditions obtain, the fibre may be prepared uninjured for the market in a reasonable time and with a minimum amount of trouble.

All these conditions are satisfactorily fulfilled in the province of Bengal and in some of the adjoining areas, as well as in Western Assam. The geological formation of India is responsible for most of the above ideal conditions, and an examination of the leading features obtaining in this area will be sufficient to explain the

existence of such conditions. The prevailing winds are north-east and north-west from October to April, and south-west and south-east from April to October. During the latter period the winds carry a great quantity of moisture, some of which is intercepted by the Himalaya Mountains. Here, in combination with the melting snows, it forms the gigantic deluges which cause the rivers to swell and to overflow their banks for miles into the adjoining land, thus moistening the soil and leaving in their tracts a rich top dressing. The water incidentally and very favourably provides adequate means for conducting successfully the processes of retting and washing, but if the monsoon rains come early, as was the case in 1913, there is a possibility of great damage being done to the young plants, as well as a tendency to produce a short-length fibre with a consequent light yield.

Cultivation.—The preparation of the soil for the growing of jute commences in the autumn, and continues at suitable and convenient intervals until the early spring. The fields are ploughed, rolled, and harrowed repeatedly during this time, to clean and break down the soil until a clean seed bed is obtained. The amount of manure which is spread over the ground depends upon the particular location, some of the low-lying lands require very little manure because the silty deposits in many cases provide a sufficiently rich soil. On the high lands, where manure is necessary, an average quantity is about five tons of cattle manure per acre. Castor-oil cake and ashes from wood refuse are also used; but whatever kind of manure is used, it is usual to introduce an amount which contains from 30 to 40 lb. of nitrogen per acre.

Many of the farming implements are exceedingly crude, and produce poor results. The ploughs are usually made of wood, and are drawn over the fields by teams of cattle. After having been ploughed sufficiently, the ground is harrowed in order to smooth it out. The harrowing is locally called laddering, because of the structure of the implement, which is a crude form of ladder made of wood, and which is drawn over the fields by teams of cattle, as in ploughing.

The time for sowing the seed depends upon the weather and upon the district; it is also influenced by the early and late varieties, or both. Sowing of the seed may be started early in February

and extend to the end of May. The hill tracts, which naturally dry quickest, are sown earliest, so that the ground may retain sufficient moisture to enable the seeds to germinate. The low-lying ground, which is subject to early flooding, is also sown comparatively early in order that the plants may be well on their way before the floods come down in consequence of the melted snow or the monsoon rains.

When the proper time arrives, the seeds, about 14 to 16 lb. per acre, but sometimes as much as 30 lb., are sown broadcast by hand and by the method known as cross-sowing that is, half-sown from east to west, and half from north to south. This method results in the seed being distributed uniformly over the ground. After the seeds have been sown the ground is again harrowed to cover the seeds, and germination takes place in from four to eight days.

If the weather is suitable it is necessary to commence weeding when the plants are a few inches high, but previous to this the fields are harrowed or laddered, an operation which opens up the surface of the ground, which has been caked hard by the combined effects of the rain and the sun; this loosening of the surface soil enables the moisture to penetrate more easily into the ground, and also greatly facilitates weeding. The process of weeding, as well as that of thinning out, is continued until the plants reach a height of 12 in. to 18 in. Four to six inches, or even more, must be left between the plants when the crop is intended for fibre, but if part of the crop is required for seed, the plants in this area require a much greater space—say, 12 in. to even 20 in.—in order that they may have every facility for branching, and so produce a greater quantity of bloom and seed. The ground for seed cultivation is sometimes prepared in drills sufficiently far apart to allow plenty of freedom for the same purpose.

Under favourable conditions the plants reach maturity in about three and a half to four months from the date of sowing the seed. Opinions differ, even among expert jute growers, as to the best time for reaping the jute crop, and three well-defined stages of growth mark the periods at which harvesting may commence:—

1. When the plants begin to bloom,
2. When the blooms are shed,
3. When the seeds are ripe.

Each of these stages of growth has its supporters, and each has its advantages. A general conclusion regarding the quality or quantity of the resulting fibre obtained at the different stages is the following:—

1st Stage: The fibre is very fine, very clean, and very easily separated from the wood and other vegetable matter; it is, however, weak, and the yield is a minimum one.

2nd Stage: The fibre is fine, clean, and strong, it is not difficult to separate, and the yield is a good average one. It is the best marketable fibre so far as quality and strength are concerned.

3rd Stage: The fibre is more or less coarse, of unequal colour, and irregular in strength, it is very difficult to separate and clean, but it yields a maximum crop.

It would thus appear that the most favourable stage is the middle one, when the blooms fall and the fruits set, and this is the one which is recommended by the Agricultural Department of the Government of India. When this stage arrives the plants are cut down close to the ground with a sickle or "daw," and when the plants are partially submerged they are either pulled up by the roots or else boys dive under the water in order to cut the plants as near to the earth as possible.

After the plants are cut down they are usually allowed to lie for a day or two so that the leaves may wither or decay, and be removed if it is thought desirable. There appears to be a good reason for this, for it is believed that if the leaves remain on the stalks during the process of retting, the resulting fibre is darker in colour than it would be if the leaves were absent, and we have already stated that a light colour is one of the qualities of a valuable fibre. It is also considered that the above practice of exposing the plants for a short time facilitates the separation of the fibre from the plants, but here again opinions differ. After the plants have been thus exposed, the tops are cut off, and the remaining portions of the plants are made up loosely into bundles of about eight inches diameter; they are then ready to be taken to the nearest tank, pond, or stream to undergo the processes of retting, rotting, or steeping.

CHAPTER II

RETTING, STRIPPING, WASHING, AND BALING OF JUTE FIBRE

RETTING.—The stem of the jute plant consists of many parts; its longitudinal form is very similar in appearance to other slender plants, while the disposition of its various parts is exemplified in Fig. 6. This is a photo-micrograph of a transverse section near

FIG. 6.

the top of a plant of the order *Corchorus olitorius*. The central part A consists of pith, the part B of wood, while between part B and the cuticle or outer covering C lie at D the groups of fibrous material which are known as jute. An enlarged view of a section, somewhat similar in size to the portion E in Fig. 6, appears in Fig. 7.

This part of the plant is enlarged 120 diameters, and the various parts are lettered to correspond with the same parts in Fig. 6. In addition, a micrometer scale is introduced, each small division of which represents $\frac{1}{2000}$ part of an inch, so that some faint idea of the actual dimensions of the various parts may be gathered In this and in other photo-micrographs the scale was not very pronounced, we have, therefore, made part of it more distinct by inking-in by hand.

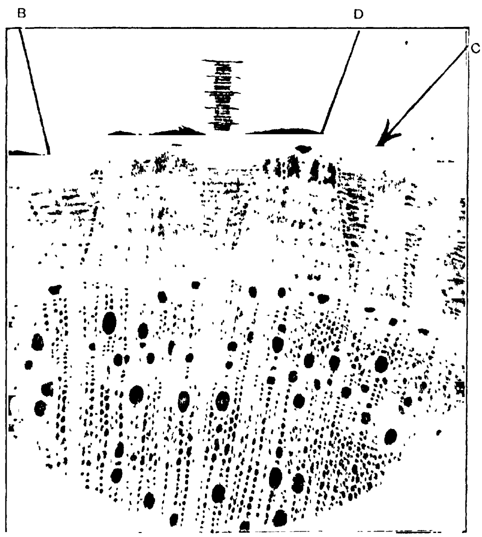

FIG. 7.

Retting is essentially a process of fermentation, and is carried out by submitting the jute plants to the action of water. It has for its aim the conversion of the insoluble gummy and vegetable matter into soluble substances, which are removed by subsequent washing operations. The fermentation is due to a bacterial agency which effects the required dissolution of the parts round the fibre without acting on the ligno-cellulose fibres. The bundles of fibres are situated as shown at G in the photo-micrograph in Fig. 8,

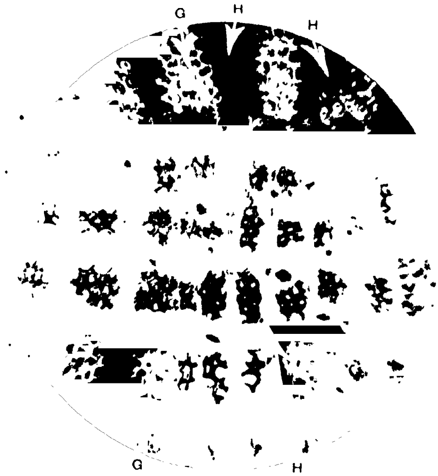

FIG. 8

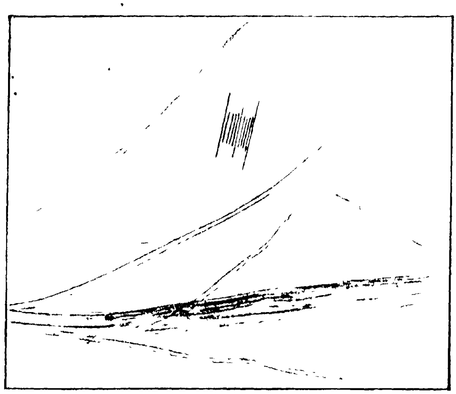

FIG. 9.

which in turn is an enlarged view of a portion of Fig. 7. It will be understood that the bundles of fibres G in Fig. 8 are surrounded by

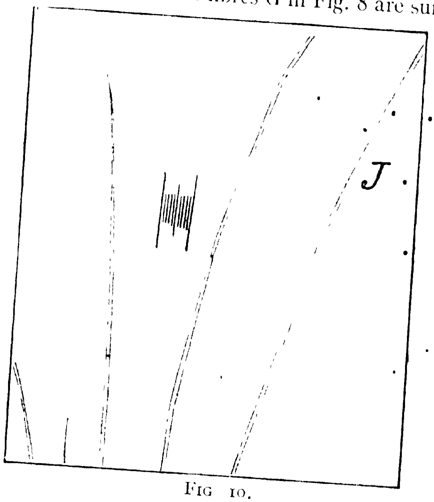

FIG. 10.

FIG. 11.

cellular tissue H, which must be removed during the operation of retting.

A longitudinal view of a bundle of cleaned fibres, such as is

illustrated at G in Fig. 8, appears in photo-micrograph Fig. 9, from which it is evident that several of the ultimate fibres have partially separated from the bundle. In Fig. 10 two of these fibres are shown at J nearly separated, the points of the fibres projecting. (These ends are, unfortunately, not visible on the reproduction.) Parts of four other fibres are illustrated in the same figure over a micrometer scale, each small division of which represents $\frac{1}{2000}$ in. Three complete ultimate fibres, partially adhering to each other, are shown in Fig. 11, the average length of the three

FIG. 12.

being about 0·14 in. to 0·16 in. A good general view of a number of the ends of a group of ultimate fibres appears in Fig. 12, also over the same micrometer scale as that used for Figs. 9 and 10, while Fig. 13 illustrates a few of the same fibres magnified over a scale each small division of which represents $\frac{1}{5000}$ in.

The ultimate fibres of jute are fusiform, and exhibit a distinct lumen. As will be seen from the figures, these ultimate fibres are thickest in the middle, and taper to each end. The measurement of the widest part is about $\frac{1}{1000}$ in., while near the ends it is about $\frac{1}{1250}$ in. The length varies from $\frac{1}{10}$ in. to $\frac{1}{7}$ in. The fibres are composed of ligno-cellulose or bastose, which accounts for the harsh

feel which the average jute goods have as compared with flax, the fibres of which are composed of pecto-cellulose. The ultimate fibres of flax are also much longer than those of jute, being usually from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. in length.

There are at least three distinct methods of retting, known respectively as:—

1. Tank, dam, or pond retting.
2. River or stream retting.
3. Field or dew retting.

Fig. 13

The particular method which is adopted depends largely upon the proximity of the jute farms to a satisfactory water supply, or upon satisfactory atmospheric conditions. With regard to the first two methods, the procedure is very similar. The bundles of plants are placed in the ponds, or in the slowly running streams, and weighted with grass clods or other available articles to keep them entirely immersed for the requisite length of time, which may be anything from two or three days to a month. A normal length of time for the operation is about a fortnight. During the fermentation (which, under favourable weather conditions, starts almost immediately) a considerable quantity of gas is liberated, so

that it is necessary to add more weight if the bundles show any tendency to rise above the surface of the water. If, in virtue of their reduced weight, the bundles float and are only partially submerged, there is a danger of uneven retting, and a consequent imperfect separation of the vegetable tissues which surround the fibres. Great attention must be paid to the plants during this rotting or retting process, because if not checked at the proper time the action naturally continues, and would, if prolonged sufficiently, ultimately ruin the fibre.

Since under varying conditions there is a great difference in the time required for the process, a period which depends partly upon the temperature and partly upon the composition and condition of the water, it is a usual practice to examine the plants early and frequently, and, when signs of rapid progress appear, they are examined daily in order to be able to remove the bundles at the most favourable time. The proper time for removing the bundles is always determined by trial, a few plants are taken out of the water, and if the fibres can be separated easily from the wood stalk and adhering vegetable matter, the retting operation is considered as being completed, and the stripping and cleaning processes follow immediately.

The ultimate value of the fibre depends greatly upon the retting process. If the operation be not carefully and completely performed, defects arise on the fibre, and these defects are difficult, and in some cases impossible, to eliminate in the subsequent operations. *Corchorus olitorius*, which yields the softer fibre, is more easily retted than *Corchorus capsularis*, the plants of which are comparatively hard, but this feature will be easily understood when the nature of the fibres is compared.

The chief objections to river or stream retting are :—

1. The risk of plants being carried off during the floodings of the rivers.
2. The time required for the operation.

R. S. Finlow, fibre expert to the Indian Government, states that "in Eastern Bengal and Assam small quantities of salts of phosphoric acid and ammonia salts accelerate greatly the retting process and improve the fibre." This is quite true, but at the same

time it is dangerous, except under efficient supervision, to introduce any of these substances. In some districts the plants in stack are allowed to remain on the land exposed to the sun for two or three days; the leaves dry and drop off, and, in the opinion of many ryots (farmers), a stronger fibre results. In other districts the root ends of the plants are immersed for a few days preparatory to the complete submersion of the bundles; this is done on the assumption that the thicker parts of the stems require more time under the water.

In pond retting there is, of course, no danger of the plants being carried away by floods. In addition, a minimum time is required; but, on the other hand, a disagreeable odour prevails.

Dew retting, as its name implies, is more or less a natural process; the plants are laid down on the ground to allow atmospheric moisture to act on them. They are turned periodically so that all parts of the plant may be treated as uniformly as possible. This process is practised little, if any, in connection with the jute fibre, but it is common enough in many flax districts. Investigation pursued under the direction of R. S. Finlow revealed the fact that when various moulds or fungi are allowed to form upon the moist stems of jute plants, they have the power to dissolve the tissue in which the fibres are imbedded. This process is obviously a type of dew retting. In some places water is collected on the fields where the plants have been cut down. When this is the case the plants are retted on the spot; but great care must be taken to see that the plants are totally immersed during the whole retting process. Whatever process of retting is employed, it is essential that the operation should be complete, for under-retting results in part of the gum remaining with the fibre, while over-retting weakens the fibre, and often results in an inferior colour.

Stripping and Washing.—As soon as the plants are in the desired condition for being removed from the retting water, they are ready for the operations of stripping, cleaning, and washing. Natives, both men and women, perform this operation, the men in the water, the women on the bank; they open the bundle, seize the end of one of the plants and break off 6 or 8 in. of the stem. The broken part of the stem is removed, and the operative slips the fingers between the bast layer and

the remaining stem, folds back the former, and strips it off the stem. The long stems are kept intact, as they are largely used for thatching purposes. The stripped bast layer is now rubbed between the hands, and washed to free it from the gelatinous and other material which is still adhering to it. When a few stems have thus been treated, the material is thrown or spread on the surface of the water in a manner analogous to that of casting a fishing line. The impurities are removed by hand, and a final washing performed, after which the water is squeezed or wrung out, and the jute fibre laid aside preparatory to drying, which in good weather takes place in a few hours. Another method of stripping is to fix two posts upright in the water, and to stretch a pole between them; the plants are then repeatedly beaten against the pole, and the impurities thus removed The fibre is then stripped from the broken woody core, and floated on the surface of the water, so that the operative may pick off any undesirable matter which still adheres to the fibre. After this process the fibre is again washed, or else removed to a clean supply of water to undergo a final process of washing. If the water supply is limited where the retting and stripping processes are performed, it is best to convey the stripped fibre to a plentiful supply of clean water for the final washing

Although it may be quite feasible to remove the stripped or separated fibre to a suitable locality for washing only, it may be quite impracticable to transport all the crop of green plants to the same place for the three operations of retting, stripping, and washing. It must be remembered that the dry fibre itself is only equal to from 4 to 8 per cent. of the weight of the plants—that is, 350 maunds (28,800 lb.) per acre of green crop yield only 14 to 28 maunds (1152 to 2304 lb.) of fibre.

After the final operation of washing is completed, the fibre is thoroughly wrung or squeezed to remove the bulk of the water, and it is then spread on the ground, or, better still, suspended on bamboo poles, to dry. If the heat of the sun is too powerful, there is a danger of the fibre becoming discoloured; whenever such danger exists, the fibre should be partially shielded from the strong effects of the sun's rays. Moreover, the fibre is never allowed to become perfectly dry, for there is a distinct understanding between

buyers and sellers that a maximum of 10 per cent. moisture may obtain in the drums or *kutcha* bales, the form in which the material is despatched to Calcutta. The usual test for moisture is to expose the fibre to the atmosphere of a covered shed for twenty-four hours, and any excess of moisture above 10 per cent. has to be allowed for, the prices or allowances being adjusted between the interested parties. When the jute is to be baled for export, it should not contain more than 13 per cent. over absolute dryness—a percentage which is considered to be a natural quantity for this material.

When the fibre has been dried to the proper degree, it is collected, and sometimes it is examined by jute brokers preparatory to being made up into rolls or bundles (termed drums), and despatched to the baling stations near Calcutta. The farmers themselves sometimes undertake the despatch of the fibre, and they attend the various bazaars to dispose of their goods. Part of the fibre is sent by rail, but the bulk is carried by small boats. The small bales weigh from one to two maunds ($82\frac{2}{7}$ to $164\frac{4}{7}$ lb.), while the *kutcha* bales contain three maunds ($246\frac{6}{7}$ lb.) or more, and they are carried from the boat to the shore by the natives, and ultimately to the "godowns," ready for the final selection and classification previous to being baled for export. If necessary, the ends of the jute fibres are dashed on to the pins of a coarse heckle board in order to remove any objectionable matter, and to improve the appearance of the fibre. The operative takes up a handful of fibres, and deftly throws the ends amidst the pins of the coarse heckle; then, by drawing the bundle towards him, he not only causes the ends to be partially split and combed, but at the same time the bulk of woody material which accompanies the fibre is retained by the heckle pins. The material is then assorted, selected, and made up into loose bundles or bojahs of 200 lb. each, and finally carried by the natives to the baling press.

Since there are so many districts in which jute is grown, and since the quality, colour, strength, and other properties vary from time to time according to atmospheric conditions, to the type of seed, to the method of cultivation, and to the particular kind of water in which the operations of retting, stripping, and washing have been performed, it is clear that it is well-nigh impossible to fix an absolute degree of equality between what are considered

similar kinds of jute grown in various districts. In spite of this obvious difficulty, the degree of accuracy achieved in the assortment by the experts is remarkable.

The quality of jute is recognised by distinctive letters, numbers, colours, simple ornament, or by a combination of two or more of these symbols, and all these are embodied in what are commonly known as "jute marks." Each baler, or each firm who employs a baler, has a number of distinctive marks by which the various grades of jute which he bales may be recognised, and each baler is prepared to guarantee his jute to be equal in quality, and similar in grade, to the same specified marks of the jute shipped at the corresponding time of the two previous seasons. Moreover, it is a common practice for some balers to guarantee their marks to be approximately equal to certain marks of other balers. This is, of course, essential when one spinner buys jute from various sources, and especially if he spins particular types of yarn. At the same time, it does not by any means follow that the best marks of all balers represent the same quality of jute, as a matter of fact, they seldom do. Thousands of "marks" appear in a book of about 350 pages issued annually by the Calcutta Baled Jute Association, and also the group of marks issued by the London Jute Association. The latter are commonly used in the trade, and supply all the information desired. If, as sometimes happens, the jute supplied is found to be inferior to the jute of an equal mark, the buyer has, in some cases, if the difference in value is excessive, the option of returning the jute; but if the difference be slight—and this may easily happen—the buyer can recover the difference in value. In both cases the arrangement is decided by arbitration.

The drums or *kutcha* bales of jute having been opened out and the fibre arranged in the various classes or grades, the material intended for export is ready for being packed in the form of bales. The dimensions of the bale in the press are 4 ft. 1 in. by 1 ft. 6½ in. by 1 ft. 6 in., so that it occupies 9·443 cub. ft., and the weight of each bale is 400 lb. The density of the jute before being removed from the press is therefore 42·36 lb. per cub. ft., or a measurement equivalent to

$$\frac{2240 \text{ lb.}}{400 \text{ lb. per bale}} \times 9{\cdot}443 = 52{\cdot}88 \text{ cub. ft. per ton.}$$

The density of the bale is, however, less than the above when it leaves the press, because immediately the great pressure is removed, the bale expands to a size which is approximately 11 cub. ft., and for freight purposes it is usual to reckon five bales per ton. Freight rates have been altered recently to a basis of 50 cub. ft. per ton.

It is desirable that the whole of the jute crop, or at least that part of it which is intended for export, should be made up into bales in a comparatively short period; hence the modern baling presses are scientifically built, not only to do the work efficiently, but also to do it quickly. There are two kinds of presses used for the baling of jute, and both may also be used for baling cotton and other fibres if desired. The first is the "Watson press," illustrated in side elevation and front sectional elevation in Figs. 14 and 15.

In these figures, A are the filling chambers, usually about 15 ft. deep, B is a support, termed the follower, which is raised when required by two hydraulic rams C. Rod D is merely a guide, and is provided at the bottom with an enlarged portion E for limiting the travel. The top follower plate F is operated by the upper pair of rams G. Hand-wheel H is connected with the plate or grid J by means of powerful pinions K and rack L. Above the upper floor or platform M strong doors N, termed filling doors, are fixed to the upper part of the filling chamber A, and the whole is supported by strong pillars O and the massive upper and lower crossheads P and Q. When the bale is complete it occupies a position in the part R.

The operation of making a bale is somewhat as follows: The operatives take up their positions at each side of the press, with the follower B about level with the platform M. The doors N of the filling box are naturally open, so that the fibre may be introduced from both sides. The follower B is lowered gradually as the filling proceeds, and by the time it reaches the lowest position (that shown in the figure), the necessary amount of material, as well as the cloth with the bale mark printed on, has been entered through the doors N, and the latter are then closed. Hydraulic pressure is now applied to the rams C, which raise the follower plate B until it reaches its highest position with the material pressed against the underside of the upper follower plate F. In order that this may be accomplished the grid J would in the meantime have

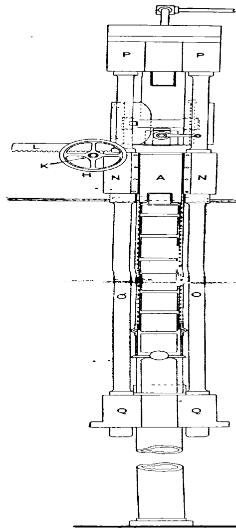

FIG. 14.

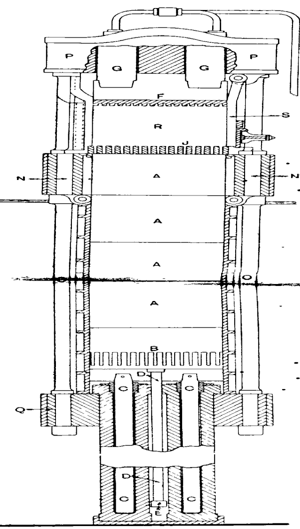

FIG. 15.

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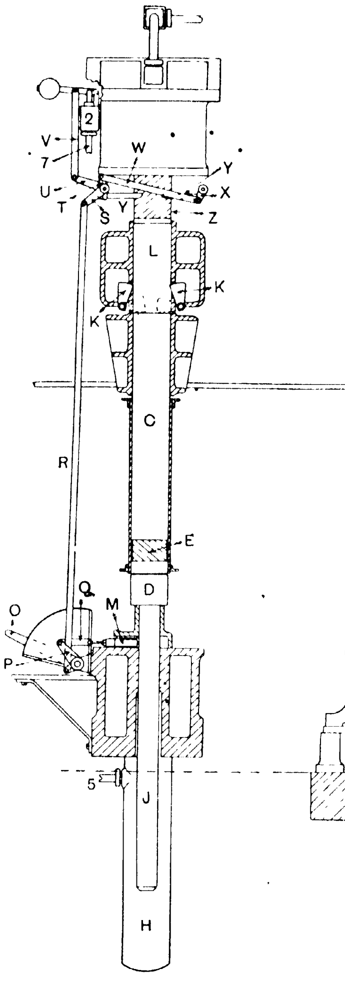
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FIG. 16.

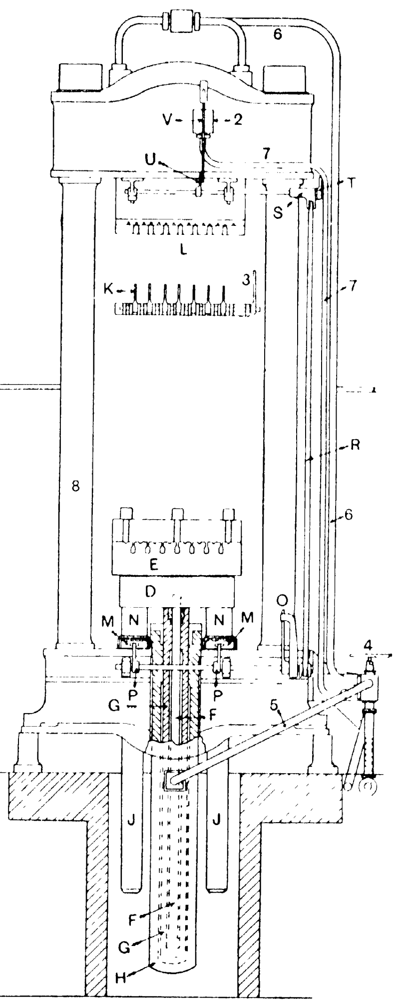
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FIG. 17.

been withdrawn completely from the chamber R by wheel H, pinion K, and rack L. When the lower follower plate B has pressed the jute into the upper chamber R, the grid J is again returned to its position in the chamber R, and thus supports the jute which has just been pressed home by the bottom follower plate B, and the latter is now at liberty to return ready for the next charge. The bale in chamber R is now ready for the preliminary roping or lashing. The ropes are cut into lengths sufficiently long for encircling the bale several times, and are marked in the centre for the guidance of the lashers, who thread the two ends of the rope by means of enormous needles through the upper and lower slots alternately. The final pressure is now applied by the rams G and the upper follower plate F, after which the ropes are made taut, the end casing doors S swung out to relieve the side pressure, and the bale ejected from the press.

It will thus be seen that there are two distinct operations proceeding simultaneously—the filling of the chambers and the roping and final pressing. Efficient as this may appear, many improvements have been introduced to economise in time, and to complete the work with a minimum amount of water.

Most of the modern baling presses are now provided with radial filling chambers, so that the filling and the pressing may be performed with the chambers in different positions. One method of doing this is illustrated in Figs. 16, 17, and 18, which show respectively the main parts of the press in a sectional side elevation, a front elevation, and a plan. The radial filling boxes are shown only in the plan view, from which a good idea of the movement of these chambers will be gathered. The filling is done in three stages, and each time a chamber is filled it is rotated into the press proper to be pressed, as follows: One chamber having been filled, is rotated until it occupies a position marked C immediately over the bottom follower plate D, which, along with the lashing plate E, is then pressed upwards, while the second chamber B (see Fig. 18) is being filled with the fibre. The bottom follower plate D is raised by means of concentric rams. The inner ram F, Fig. 17, works in the hollow part of the second chamber G, and both are enclosed in the chamber H. The bottom follower plate D is guided in its upward and downward movements by the two guides J.

When the parts D and E have been raised by the ram F, and have carried the material to the top of the chamber C, Fig. 16, the further upward movement of the fibre causes the supporting fingers K to be rotated from their dotted positions to the positions marked in solid, and thus the material, as well as the upper part of the lashing plate, is capable of being forced into the upper or fixed baling chamber or press L. Immediately the material and the upper part of the lashing plate E are clear of the supporting fingers K, the latter, in virtue of gravitational force, drop to their normal or dotted positions in the drawing, and thus form supports for the

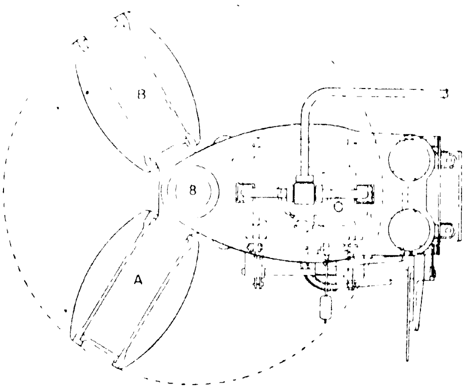


FIG. 18

first charge of material when the bottom follower plate D and the lashing plate E descend, the slots in the upper part of the latter enable it to descend even when the fingers K are horizontal. The descent of parts D and E commences as soon as the outlet valve to the small ram F, Fig. 17, is opened. It is of course understood that during the upward and downward movements of the lashing plate and bottom follower plate D a further supply of fibre is being introduced into the second radial chamber B, Fig. 18, so that it may be rotated over the lashing plate as soon as, or immediately after, the latter reaches its lowest position. The inlet valve of ram G, Fig. 17, is now opened, and the water forces both rams and the second charge of material into the fixed press L as before, after

which the rams, follower plate D, and lashing plate E, descend in order to take, in a similar manner, the third and last charge from chamber A to its destination. When the three charges have been thus forced into the fixed press L, and while the parts D, E, and J are still in their highest positions, the whole is supported by slides M, Figs. 16 and 17, which are pushed into the slots in pillars N, and thus pass under the extremities of the guides J. The insertion of these supporting slides M by means of levers O and P and arm Q, results in an upward movement to connecting-rod R, and this clearly rotates levers S, T, and U, arms V and W, and lever X. The upward movement of connecting-rod R results in the withdrawal of locking plates Y, so that the upper or finishing rams, which are enclosed in the top crosshead and attached to the upper follower plate Z, may descend and apply the final pressure to the bale. Previous to this motion, however, the locking fingers K are rotated, and the bottom follower and lashing plates support the bale. When the final pressure has been applied, the ropes are adjusted, and the bale taken out ready for a new bale to be made in precisely the same manner.

It will be observed that the insertion of the locking slides M is accompanied with the withdrawal of locking plates Y, and *vice versa*. When the latter are supporting the upper follower and rams the valve *2* is open, so that if the inlet valve to these rams be accidentally opened, or opened at the wrong time, the inrush of water may escape by the valve 2, and thus prevent damage.

Although the supporting fingers K are pushed upwards by the material, and fall in virtue of their own weight, they may, if necessity arises, be manually operated by handle 3, Fig. 17. Valves 4 are naturally provided for the various rams, the pipes leading from the bottom inner ram F and the upper rams being shown at 5 and 6, while the waste pipe from valve 2 is shown at 7. Guides and easing doors are not shown in these figures, but they are similar to those illustrated in connection with the press already shown in Figs. 14 and 15. The radial filling chambers rotate about pillar 8, Fig. 18, as a centre.

Perhaps the latest word in regard to such presses is the modern Watson-Fawcett "Cyclone" press, which may be considered to be a practically perfect combination of mechanical and electrical

parts. This type of press is in use at many of the modern baling stations, and large quantities of material are turned out in a comparatively short time The press must of necessity be constructed in a very substantial way. It is easily operated, can be run a considerable time with little risk of breakdown, is economical in water consumption, and requires a minimum number of work-people to manipulate the various operations From twenty to thirty bales per hour can be packed and turned out of the press which is illustrated in Figs 14 and 15, but with the improved Watson-Fawcett "Cyclone" press working in duplicate, and with pressures up to 6000 or 7000 lb per sq in, it is possible to pack 130 bales per hour, and to continue at this rate for long runs. It is usual, however, to pack about sixty bales per hour, or one per minute, in a single press

This modern press embodies practically all the good points of the other presses, including somewhat similar radial boxes to those shown in Fig 18, and these boxes, in conjunction with the other mechanical parts, permit of the continuous action of all the sections of the press, thus enabling the various operations to be conducted simultaneously The rams for the final pressing are under the fixed press, so that the upper part only of the filling chambers rotates to place the material in the fixed press. A very good idea of the nature and construction of the filling boxes, the rotating chamber or press, and the casing door, will be obtained from Fig 19.

Placed in close proximity to the press is a pair of large scales in which the requisite quantity of material is weighed The fibre is then taken, and part of it is deposited on each side of the filling chamber, where it is entered through the open doors of the inoperative box (say A, in Fig. 18). This figure is actually the plan of the press illustrated in Figs. 16 and 17, and is referred to here simply to show the positions of the rotating parts, which operate similarly in both types of press The material is spread on the bottom follower plate as the latter is descending, until 400 lb. has been added, and upon the top is placed a piece of cloth, usually hessian, with the bale mark printed thereon. The doors are then shut, and the preliminary pressure applied. The ram forces the material into the upper box, and the lashing plate is locked in position by the angle plates shown at the bottom of both boxes. When this is

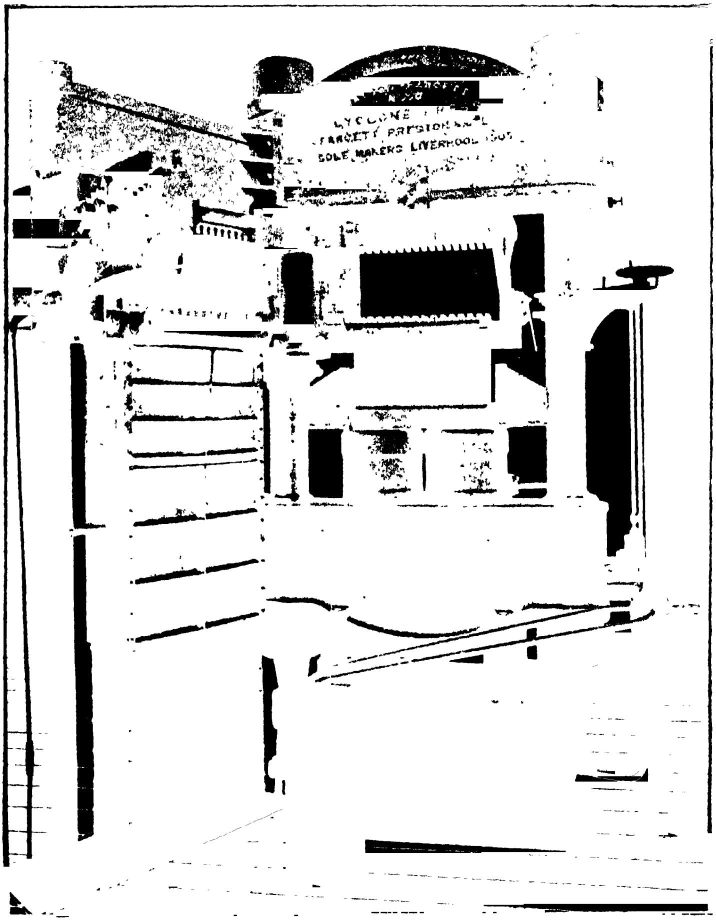


Fig. 19.

done the boxes are rotated through 120° to bring the box C, Fig. 18, above the filling chambers, to take the one which has just been filled to the position marked B for the preliminary lashing of the bale, and to place the one which has just received this preliminary lashing under the crosshead of the press. After the preliminary lashing is completed the boxes are rotated through a further 120°, which carries the partially pressed and lashed bale into the press, where the final pressure is applied. The bale, when finally pressed and lashed, is pulled or pushed out of the press on to inclined rails, from which it drops through a hole on to a chute, and so reaches the floor of the lower storey. It will thus be seen that the following operations are performed simultaneously in boxes A, B, and C, Fig. 18:—

A. The filling of the chambers with the heads of jute, and the preliminary pressure;

B. The preliminary lashing;

C. The final pressure and the final lashing.

Since the rate of delivery is approximately one bale per minute, it follows that the completed bales are being continually delivered to and removed from the bottom of the chute. When removed they are taken to be measured and weighed by licensed measurers and weighers sent from the Chamber of Commerce to fulfil these duties for all jute which is to be exported.

It now only remains to take these bales to the steamers, ready to be despatched to their destination. With the gradually increasing demand for jute, and the huge quantities which are yearly exported from India, it is only natural to expect that the present day conditions are quite different from those which prevailed in the days when the comparatively small sailing vessels conveyed the jute from India to the ports of London and Dundee. At that time the work of gathering up the fibre, and the actual operation of baling, were not done so quickly, neither was the delivery as urgent as it is at present, nor so diversely distributed. It was a common occurrence for a vessel to take anything from 80 to 120 days to make the passage from Calcutta to Dundee, and the period during which jute was landed in Dundee extended over several months—in fact, nearly throughout the year. The cargoes now are exceedingly large, and sometimes reach nearly 50,000 bales; the passage

is made in 26 to 45 days, and the delivery limited practically from October to March. Immediately the vessels arrive in Dundee preparations are made for unloading. Long chutes are placed against the side of the vessel. The bales, after being lifted from the hold by a small hydraulic engine, are deposited at the top of the chute, down which they slide, to be expeditiously removed by the dock labourers.

The weighing of 10 per cent. of the bales is undertaken by the harbour officials for the purpose of fixing the dues—hence the term "harbour weights.") It is also customary for some representative of the buyer to attend at the wharf to see these bales weighed, and also to see that the correct marks are received. In some cases all the bales are weighed. When this method is adopted a small charge per bale is naturally made.

CHAPTER III

MOTIVE POWER. ARRANGEMENT OF MACHINERY IN A TYPICAL JUTE MILL

ONE of the first considerations in the equipment of any modern spinning mill is that of the motive power, not only with regard to the initial cost and the actual horse-power of the plant, but also in regard to the quality of the drive, and the probable expense of upkeep. The machinery in a jute mill, and particularly that for the carding and subsequent processes, requires a steady drive; fortunately, the sources of power now available are greater than ever owing to the development of engines of various types, as well as the methods of electrical driving from current produced by public, private or by local power generating stations.

For some considerable time after the method of obtaining power by water and water wheels was practically eliminated by steam-power, it was almost a universal custom to have wheel gearing from the engine to the main shafts, and then to communicate the motion to secondary shafts either by similar gearing or by belts. Water power is still used in a few places, but, in general, the resulting drive is far too erratic for modern preparing and spinning machinery. And although the above-mentioned method of conveying the motion from the steam engine to the secondary shafts of the mill possesses certain advantages—there are still a few well-equipped mills in which the gear system prevails—it is exceptional to find such equipment in modern preparing and spinning mills.

Speaking generally, there are five sources from which the necessary power may be obtained, viz., water, gas, oil, steam, and electricity. The conditions which would lead to the selection of any one or more of these fluids would naturally depend, *inter alia*, upon the proximity of the work to a cheap and efficient supply. Great developments have been made in the construction and efficiency

of oil engines and of suction gas plants, but the application of these types to the particular purpose of generating power for driving jute mills is, as yet, infinitesimal when compared with the various types of steam engines and the most modern electrical drives. And, excellent as the three former are for certain cases and under special conditions, we prefer to limit our remarks to the drives obtained by means of steam and electricity.

The following modern sources of energy obtain in the various jute mills :—

Compound side by side condensing, or cross compound horizontal engine.
Compound condensing vertical engine
Compound triple condensing engine. (This type may have a turbine auxiliary for low pressure if the main engine has been designed to suit this addition.)
Turbine.
Turbo-electric.
Electrical drive for main shaft.
Direct electrical drive on various shafts.
Individual electrical drive direct to machine.

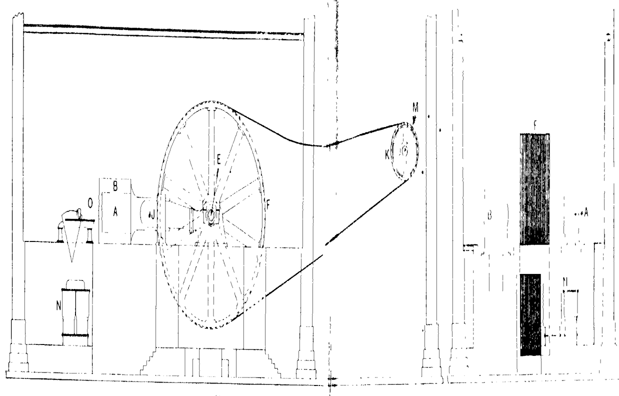
In many of the large mills, compound engines of modern design are installed, and since reliability and steady running are so essential, the engines are usually erected with a safe margin of power to meet all demands and to overcome any irregularity in the power demanded during the working day.

Messrs. James Carmichael & Co , Ltd., Dundee, have probably equipped the majority of jute mills in the world with steam plants. One of their modern compound side by side or cross compound condensing horizontal engines, capable of developing 1500 horsepower, is illustrated in Figs. 20 to 24. We have chosen this particular power in order to show the size which is desirable for driving all preparing and other machines for a mill containing approximately 10,000 spindles.

The high-pressure cylinder A is 26½ in. bore, while the low-pressure cylinder B is 55 in. bore. The steam is admitted to the high-pressure cylinder at practically 170 lbs. pressure, and through the usual connections imparts motion to the cranks C and D,

Fig. 20.

Fig. 21.



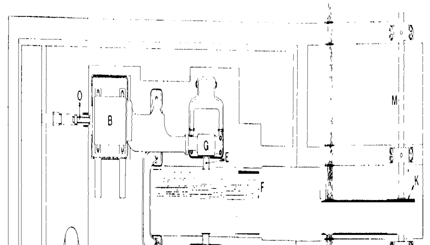


Fig. 22

Fig. 23

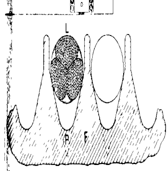


Fig. 24

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Fig. 23, at right angles to each other, on the main shaft E. The main shaft E, upon which is fixed the main driving rope pulley F, is supported in the bearings G and H, Fig. 22. The connections between the cranks C and D and the cylinders A and B are not shown in the figures, but part of the slide rod of the high-pressure cylinder is shown at J, Fig. 20. The cranks are 2 ft. 6 in., thus giving a 5 ft. stroke, and the latter, with seventy revolutions per minute of the rope pulley F, represents a speed of the piston of

$$5 \text{ ft.} \times 2 \times 70 = 700 \text{ ft. per minute}$$

The maximum piston speed recommended is approximately 720 ft. per minute.

The diameter of the main pulley F is 22 ft., consequently:—

$$22 \text{ ft.} \times 3{\cdot}1416 \times 70 \text{ r.p.m.} = 4838 \text{ ft. per minute of the main driving rope}$$

For certain purposes there appears to be a tendency greatly to increase the speed of the main driving ropes, even up to and exceeding 7000 ft. per minute, but the above-mentioned recommended speed is common in many textile mills, and is, according to C. N. Pickworth's table of speeds, the most efficient one. It is seldom exceeded for driving purposes in jute mills, and such a speed with 2-in. diameter ropes is capable of developing a little over 60 h.p. per rope. It is usual, however, to adopt a slightly lower value per rope, and twenty-eight ropes are often used for developing 1500 h.p. All things considered, we think that there is an advantage in using even more ropes for this power, and in the illustrations which we have submitted there is a 32-grooved driving pulley. Over this pulley F, and over the smaller pulley K of 6 ft. 8 in. diameter, are seventeen ropes L. The smaller pulley K communicates motion to the main shaft M of the spinning department. Other fifteen ropes, not shown in these figures, but which will appear on a much smaller scale in the mill plan, drive another pulley of 8 ft. 2 in. diameter, this latter pulley is situated to the left of the main pulley F with regard to Figs. 20 and 22, and transmits the power to the remainder of the machinery. The condenser is outlined at N in Figs. 20, 21 and 22, and is operated from the tail-rod O of the piston of the low-pressure cylinder B, an arrangement which is advisable in an engine of this type.

A section of the rim of the main rope pulley F on an enlarged scale appears in Fig. 24; the illustration shows two complete grooves formed with an angle of 45 degrees, as shown by the two converging lines P. In pulleys for smaller ropes, this angle is sometimes made 40 degrees.

When a considerable number of different departments are driven from one source, say from a large engine such as any of the above-mentioned, the transmission of the power may be by means of wheel gearing, wide belts or ropes. Driving by either straight or helical wheels is positive, requires less space between the centres, is suitable for changing the direction of motion if necessary, is proof against fire and atmospheric changes, is performed with a minimum amount of friction, and the installation, including the foundations, is usually very substantial. On the other hand, it is noisy—although this defect except on main drives may be minimised by the use of wooden or raw-hide teeth and liable to breakdowns involving frequent repairs or renewals of parts, requires lubricating frequently, involves a great initial cost, and usually demands a considerable amount of attention It is probably on account of these disadvantages that this method of driving, except where space is unavailable for other methods, has been practically supplanted by rope driving The initial cost and the difficulty of handling very wide and long belts are also obstacles to the adoption of belts for main drives.

In practically all modern steam-driven mills, and in nearly all others where the drive is not absolutely direct to the shafts, the method of driving by means of ropes obtains. Many of the difficulties in connection with power transmission in jute mills have been due to the narrow margin of power which the driving arrangement has been capable of transmitting Any defect in this respect may be much more satisfactorily solved with ropes than with any other method, provided that sufficient grooves are available in the rope pulleys, or that space is available for an additional pulley. It is partly for this reason that we advocate thirty-two ropes instead of twenty-eight for the engine illustrated in Figs. 20 to 24. Imperfections exist in all types of material, and, although all ropes are made as perfect as it is possible to make them, and also tested, it is quite possible that one or more may, through some unforeseen

circumstance, give way at an inopportune moment. If the margin of power is sufficiently great, such an occurrence would not sensibly alter the efficiency of the drive for the short time which must elapse, without stoppage of the works, before the defective or worn-out rope or ropes can be replaced. Then again, it is better to have an extra rope than to be compelled to use rope dressing, for, with the additional power obtained by the extra rope, it will not be so essential to keep the ropes very tight with the consequent replacing and temporary splicing so often found compulsory on poor or inefficient drives.

Ropes of large diameter are often of great advantage for use on large pulleys, but it is seldom that a diameter of 2 in. is exceeded for ropes for textile works, and these are used only for transmitting the power from the main shaft to the secondary ones. Ropes of 1¾ in., 1½ in., and 1 in. diameter are used according to circumstances, and, although a speed of from 4500 to 5000 ft. per minute is often recommended for main drives, a lower speed may obtain for ropes on the pulleys of secondary and other shafts.

It is a well-known and largely observed rule that the diameter of the smallest pulley should be at least thirty times that of the rope which runs on it, and better results would probably be achieved if the diameter of the pulley were forty times the diameter of the rope. Since cotton fibre is more flexible than hemp, it is natural to expect that ropes made from cotton are eminently suited for small pulleys, but for large pulleys, ropes made from Manila fibre give excellent results with a minimum amount of attention and expense.

In all cases it is advisable, if at all possible, that the top side of the ropes should be the slack side, as indicated in Fig. 20, so that a maximum grip of the pulley will be obtained; and it is also advisable that all splicing and fixing should be performed by experienced workmen—it is the cheapest way in the end. When the driving ropes go in both directions, as would obtain probably in the complete equipment for the engine illustrated in Fig. 20, and as actually obtains in the mill plan to be illustrated shortly, the conditions mentioned in the first part of the above sentence cannot possibly be fulfilled.

Five 30 ft. by 8 ft. Lancashire boilers, one as a reserve, are required to supply the necessary steam at 170 to 180 lb. for the

motive power and for heating purposes generally, and Figs. 25, 26 and 27 illustrate one way of arranging this important part of the equipment. The five boilers, with plan view of top fittings on one of them, are shown at A, B, C, D, and E, in Figs. 26 and 27, while the dotted part at F represents a position reserved for an additional boiler if and when required. The economiser pipes are illustrated at G, Fig. 26, and it will be seen that there are five sets with ninety-six pipes in each set—the whole being enclosed in the usual chamber H. Four of these sets are in section, while the fifth set, the one on the left, shows the mechanism for driving the scrapers; the latter encircle all the pipes, and since they move up and down, the soot is prevented from accumulating on the pipes, and thus prevented from reducing the efficiency of the plant.

The water from the pumps enters the economiser pipes by pipe J, and, following the direction indicated by arrow K, passes through all the sets G and emerges at L to be ultimately conducted to the pipes M at the front of the boilers and admitted to the latter when necessary. During its passage through the various economiser pipes G, the water is heated, say to a temperature of 220° or more, by the heat from the flue gases and by the flames which enter the economiser chamber H at N and pass between the groups of pipes in the various sets G, the flames and gases finally enter the chimney O. If the economiser is out of order or under repair, the water may pass directly from the pumps along the front set of pipes M to the boilers in the direction P.

Fig. 26 is a front and sectional elevation of the boilers in which the boiler A is an ordinary one provided with the usual fittings. It will be understood that the heated water, or cold water if the economiser is out of action, enters the boiler A through valve Q. In this particular case, the pipe M is shown coming from the floor, whereas in boiler E, the corresponding pipe M is shown coming from above, both arrangements are common. The latter boiler is illustrated as being fitted with the Meldrum, Bennis or other mechanical stoker. The illustrations B, C and D in Fig. 26 are sections through the places marked with the corresponding letters in Fig. 27. The partitions marked R in four of the boilers, and in the reserved one, are sometimes omitted as shown in boiler B. The space S in front of the boilers is naturally meant for the coal supply and conveyors.

Fig 25

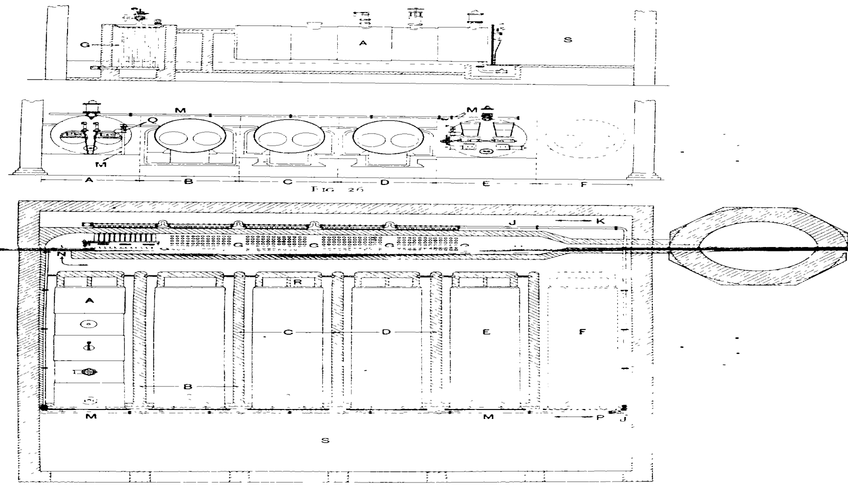


Fig 26

Fig. 27.

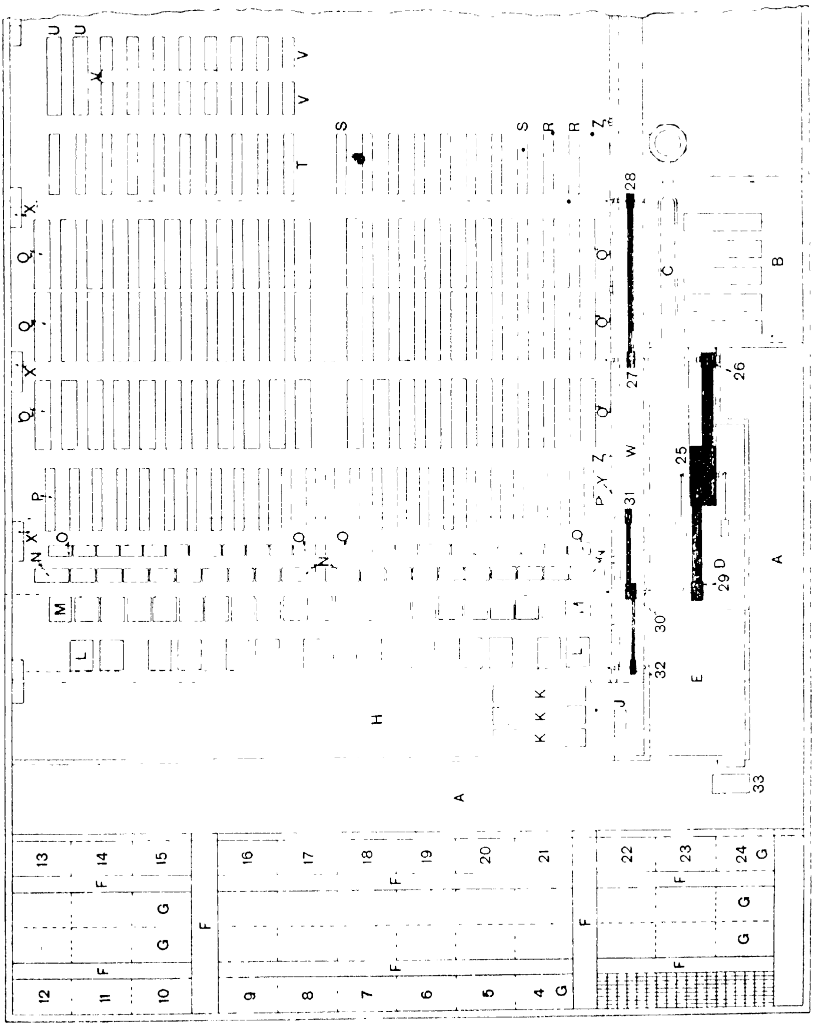
(To face p. 42)

Fig. 25 is a longitudinal elevation of boiler A, and shows in ldition the economiser pipes, the chamber for holding them, the echanism for operating the scrapers, and the usual boiler fittings

The frontispiece illustrates quite an up-to-date power plant, is a turbo-generator of 1000 kilowatt capacity, and supplies the ower for all the machinery in the Hillbank Jute Works of Messrs imes Scott & Sons, Ltd, Dundee. In the upper photo the irbine on the left is connected by a shaft to the electric generator i the right, and the latter provides the current for the motors he separate condensing plant is illustrated in the lower photo ith the necessary pumps for the turbine The centrifugal pump i the left is for the cooler, while the feed pumps for the boiler are i the right The main cables are shown clearly on the extreme ght of the lower photo; these cables lead to the above-mentioned otors which drive the shafts for the spinning and some other epartments, suitable couplings being fitted to the motors. The gatives were taken while the engine was in motion, and the productions indicate clearly the steadiness of the drive.

The condensed steam from the engine is measured as a test of ie efficiency, and the following table of particulars, as the result [two tests, may be of interest :

	Test A	Test B
Dates of two tests . .	22 11-15	23 1-18
Kilowatt load .	950	810
Steam pressure per square inch lbs absolute	170	157
Steam temperature degrees Fah	557	410
Condenser pressure per square inch lbs absolute .	0·885	1 267
Temperature of ingoing circulating water degrees Fah. .	62	72
Temperature of outgoing circulating water degrees Fah	75	84
Air Pump Discharge degrees Fah.	75	87
Total Air Pump Discharge in lbs per hour	15,000	15,578
Total Heat in Steam B T U per lb	1,297	1,240
Heat rejected : B T U	1,036	1,006
Available Energy : B T U	370	325
No of lbs of Cooling Water per lb condensed	79 5	84
Total no. of gallons of cooling water per hour	109,000	130,000
Pounds of steam per kilowatt hour . .	15 8	19·15
Turbine Thermal Efficiency .	0 584	0·548
,, Standard ,, . .	0·580	0·602
Condenser Efficiency . .	0·285	0·262



While all power plants are usually compared for economy only, the question of efficiency of the drive is also very important, a spinning mill may give greater efficiency and production at a slightly higher steam or power consumption than is considered economical from other respects since uniformity of speed may, and usually does, result in a low percentage of waste.

Several mills are now driven entirely by means of electricity, and if water power again becomes important, it will be as a generating agent for electrical purposes. Although one large motor is occasionally adopted for driving all the machinery in one flat or department, the general plan appears to be group driving, and often line-shaft driving as in the case of the turbo-electric drive. The motors are usually fixed on the ends of the shafts, unless low speeds are desired, in which case they may be situated on the floor and the necessary speeds of the shafts obtained by suitable reducing gear. Occasionally the various machines are individually driven by motors of suitable power.

The machines in a jute-spinning mill are sometimes classed and arranged in what are termed "systems," each system consisting of one breaker card and two finisher cards, or two breaker cards and three finisher cards, and the necessary number of machines of various types which are capable of dealing with the output from the three or five cards as the case may be. It is essential for various reasons that the machines should be so arranged that the work may be continuous—*i.e.*, the production from the machines should always move in the same direction, from one end to the other if the mill is one storey only. If built in flats, the same progression should be maintained, so that no part of the material in process of manufacture may travel over the same ground twice.

Fig. 28 illustrates an arrangement of the first type of mill, the various departments and machines being indicated as follows:—

A = the yard.
B = boiler-house, containing five boilers and space for an extra one (see also Fig. 27).
C = economiser chamber.
D = engine-house containing compound side-by-side engine of 1500 h.p. (see also Figs. 20 to 24).
E = mechanics' shop.
F = roadways in jute store or warehouse.
G = piles of jute in bays 1 to 24.
H = batching-house.

J — bale-opening machine.
K — 3 softening machines.
L — 14 breaker cards
M — 21 finisher cards
N { 16 push-bar 1st drawing frames, 2 heads
  { 4 ,, ,, ,, 3 ,,
O = { 20 push-bar or spiral 2nd drawing frames, 2 heads
  { 2 ,, ,, ,, ,,
P { 20 roving frames, 56 and 64 spindles
  { 3 ,, ,, for sacking weft
  { 1 ,, frame for gill spinning
Q 63 pairs spinning frames, 80 spindles on each side
R 2 pairs stop motion twisting machines, 60 spindles on each side.
S 8 pairs roll or spool winders, 40 spindles on each side
T 10 pairs cop winding machines, 60 spindles on each side
U 2 linking machines for making dry warps or chains
V 16 double reeling machines, 24 per side
W rope race or alley
X water-closets
Y presses for clothing
Z wash basins and drinking fountains
1 to 24 24 bays along wall sides of jute warehouse, 3 bays shown stored with 162 bales of jute in a layer. The rectangular spaces on both sides of roadway F take the same number
25 main rope pulley (same as F in Figs. 20 to 24).
26 pulley on main spinning shaft
27 } 28 } pulleys for spinning shafts
29 } 30 } 31 } 32 } pulleys on shafts for preparing machinery
33 — weighing machine

Since a mill of the above size will consume approximately 850 to 900 bales of jute per week on the basis of hessian yarns, or 42,500 to 45,000 bales per year of fifty working weeks, it is essential, or at least desirable, that the jute store should be large enough to accommodate this number, and hence these stores are of considerable size. Not only should there be ample room for storing the raw material, but the various "marks" or qualities should be so arranged that any number of bales from each group may be easily removed when wanted. Each rectangular space or bay G in the warehouse is capable of accommodating 54 bales of 400 lb. each in one horizontal layer, as will be seen by the group of 162 bales shown in bays 1, 2, and 3. And since there are 48 bays in all, and the bales are usually piled 14 in height or in one tier, it follows that ~~the store~~ will hold—

54 ~~bales ×~~ 48 bays × 14 bales high = 36,288 bales,

a little less than a year's supply The vertical rows or tiers from the roadway of the warehouse towards the wall, or towards the middle of the warehouse, are drawn from in regular order, and all the bales in one tier of 126 bales are of the same kind or mark It is considered a wise plan to leave a space of from one to two feet between the bales and the walls, so that the material may expand without damaging the walls in case of fire when large quantities of water are directed to the bales

CHAPTER IV

BATCHING

The first lot of jute which arrives at the mill warehouse from the harbour is taken to some convenient part of the store, or into a special room, for the purpose of being examined by the jute buyer. The characteristics of each lot, as well as the price, date of arrival, and other details, are noted and entered into the "jute-purchase" book, or the "reports" book, for future reference, and if any departure has been made in either quality or condition of fibre, arbitration may be demanded, and if the demand is legitimate, an allowance be granted.

According to the Spot Jute Sale Note, the allowances made by the seller for damages are as under:—

(*a*) *External Damage*

For 1st class damage	5%	of contract	price,
,, 2nd ,, ,,	15%	,,	,,
,, 3rd ,, ,,	25%	,,	,,
,, 4th ,, ,,	35%	,,	,,
,, half-rotten	50%	,,	,,

—such damage to be ascertained on delivery, and if not so ascertained, or if delivery not taken within fourteen days of date of sale, only Ship Side Amount and Classification (if any) to be allowed for.

(*b*) *Internal Damage.*—This is ascertained by agreement or arbitration, but no allowance to be made unless claim therefor is intimated to seller within thirty days of date of sale.

Jute should always be examined under similar conditions with respect to light, and, if possible, always by the same person. The chief points to note are: Colour, strength, length; freedom from faults such as specks, roots, moss, runners, red ends. In new jute, crop end, damp, or excess moisture should be looked for.

In some branches of the textile industry the mixing of various qualities and colours of the same material, or of different materials,

is termed "blending", in the jute industry the equivalent operation is termed "batching," and the number of bales to a group which are taken for the production of a certain class of yarn is invariably termed the "batch". The word "batching" is used, however, in a more extended sense, and is usually considered as an operation which embraces all processes preparatory to carding.

In consequence of the gradually increasing growth of the jute trade in regard to additional varieties of fabrics, there is a large variety of different yarns spun for the trade. Some of these yarns are known by some special designation as regards quality, etc., and in such cases it is unnecessary to vary the qualities and the number of bales of each mark or quality for the batch. At other times it is necessary to match a particular yarn, and under such circumstances a special batch may be selected to suit. Whichever type is required, a similar method is followed. A certain number of bales are arranged for the yarn, and this number constitutes the batch. The number is made up of a suitable assortment of bales from the various marks in the store, and the batch may contain any number of bales from four up to fifty, or even more. It may be necessary to refer to the "reports" book in order that accurate work may result, and when the final selection is made, a "batch ticket" containing all particulars is made out and given to the foreman batcher. A typical batch ticket appears below.

EXCELSIOR WORKS

March 16, 1920.

125 Tons G.H. Quality 8 lb Warp

Bale Mark	Name of Importing Vessel	Number of Bales	Number of Bay in Jute Warehouse
Dacca 4	S.S. Matin	2	7
Rajendra (*circle*) 5	S.S. Matin	1	Opposite 10
Do. 5	S.S. Matin	2	10
Sikdar (*double triangle*) 3	S.S. Clan Macdonald	2	15
P.N. (*diamond*) 3	S.S. City of London	2	6
D.S. (*diamond*) 2	S.S. Matheran	1	22
		10	

BATCHING.—There are two methods of batching followed in the preparation of jute fibre, and these are termed "machine-batching" and "hand-batching." They differ only in the way in which the fibre is lubricated, for in both cases similar machines are used for the remainder of the process. Machine-batching is almost universally practised in the trade, and is usually considered to be the better method if sufficient care is exercised, and particularly so where large quantities of fibre have to be treated. Nevertheless, a few firms adhere strictly to what is termed hand-batching, whether the quantities involved are large or small. Each method possesses

FIG. 20

advantages, and in both cases the machines which are used are known as the "bale opener" and the "softener."

The machine termed the "bale opener" appears in a certain sense to be misnamed, for its function is not that of opening the bales, as one would imagine, but that of crushing and opening the heads of jute of which the bales are composed, in order to prepare these heads for the subsequent processes, and incidentally to remove the loose dust and sand, as well as other undesirable matter which may be enclosed in the bale.

It will, of course, be quite evident that after the fibre has undergone such a severe form of packing or pressing as already described, the constituent parts of the bale are pressed into small bulk, and

the heads of jute, when removed, appear more like solid blocks of wood than of fibre, and it is in consequence of this compact form that some such process as that provided by the bale opener is necessary

The routine of the batching department is as follows: The bales which constitute the batch for the desired kind of yarn are arranged conveniently for being handled by the feeder at the back of the bale opener, two general views of one type of which are illustrated in Figs 29 and 30 Fig 29 shows one head of jute between the crushing rollers, and another head on the feed table, while

FIG. 30

Fig. 30 illustrates a head of jute being delivered. Both views show clearly the construction of the rollers.

When the bales have been delivered behind the machine, the lashing or binding ropes are cut off, tied up, and placed on one side for special treatment, and the bale marks collected for future checking. There are 6 lb. of ropes on each bale, and each rope is made from long jute. Then the layers or heads are placed successively on the travelling apron of the machine, as is clearly illustrated in Fig. 29. The actual part played by these machines will be understood by reference to Figs 31, 32, and 33, which indicate respectively side elevation with details of crushing rollers, part sectional front elevation, and plan of the Butchart bale opener as made by Messrs.

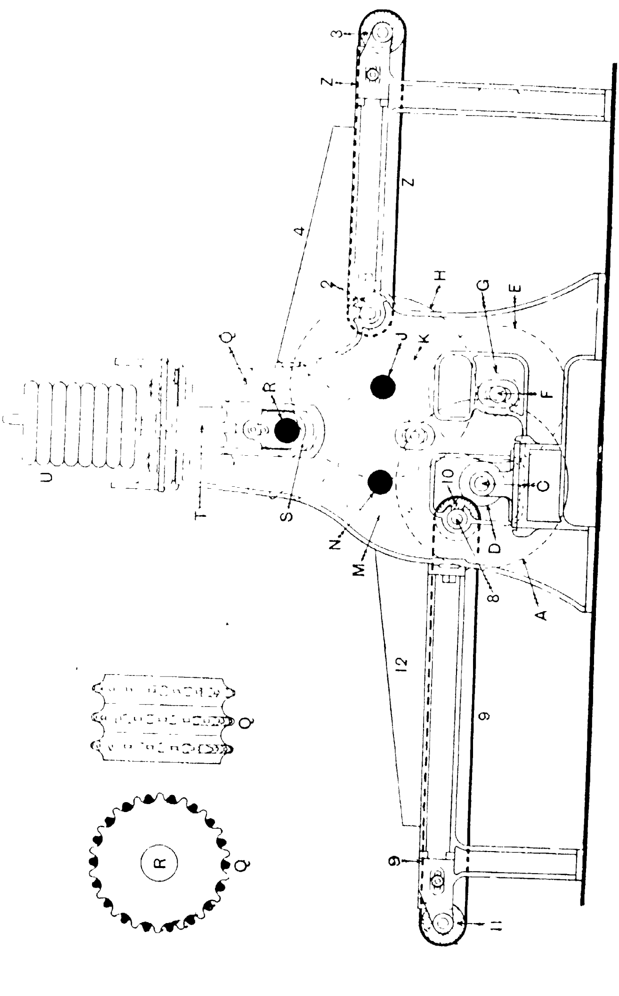


FIG 31

Charles Parker, Sons & Co., Dundee. When operated by a belt, the machine is placed in and out of action by the usual fast and loose pulleys A and B on the main shaft C. Shaft C extends to the other side of the machine, and carries a pinion D of 15 teeth, which gears with the large wheel E of 50 teeth on stud F. Wheel E and pinion G of 11 teeth are compounded, and the pinion G gears with

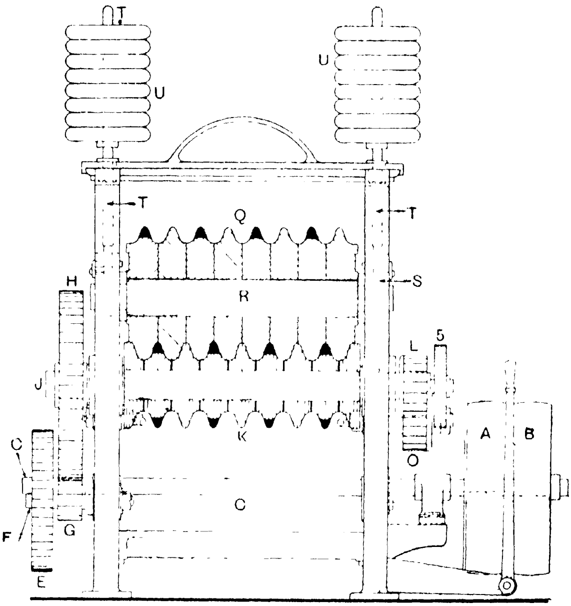


Fig. 32.

and drives wheel H of 57 teeth on shaft J. Upon the shaft J is fixed the front lower crushing roller K of about 12 in. diameter over-all.

Returning again to the driving side of the machine, it will be seen that a heavy shrouded wheel L of 18 teeth is keyed on the end of the front lower roller shaft J, and this wheel L communicates its motion in the same direction to the companion back lower roller M, on shaft N, through the medium of carrier wheel O and wheel

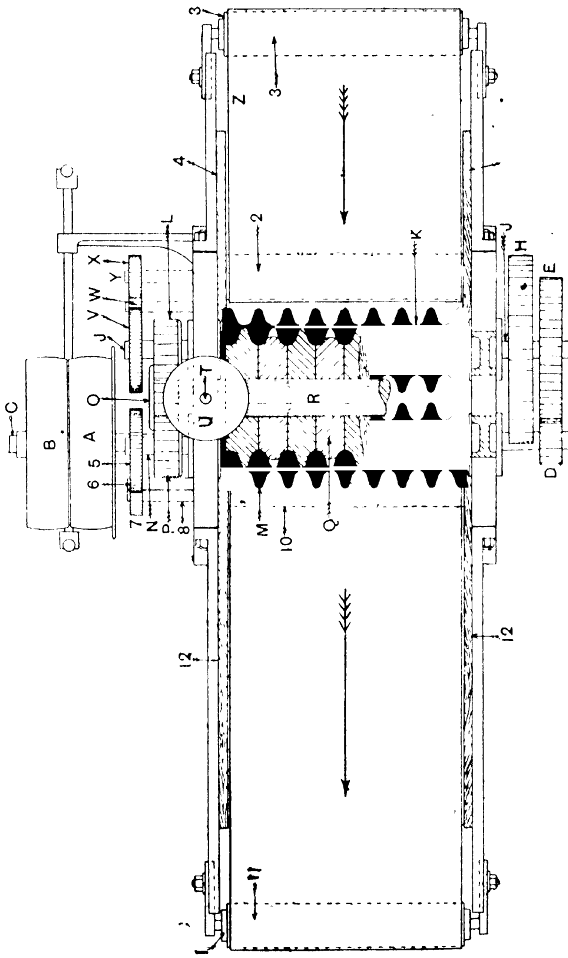
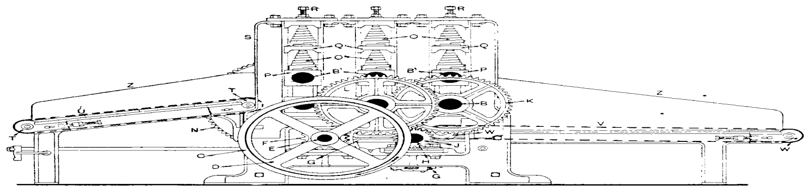


FIG. 33.

Fig. 34.



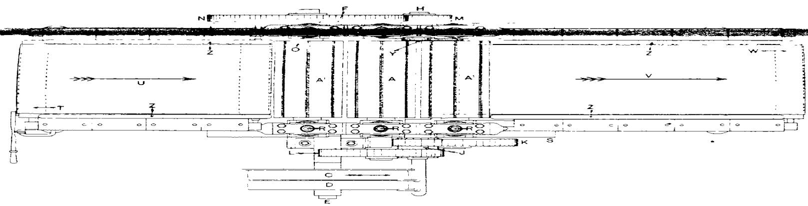


Fig. 35.

[To face page 54

P on shaft N; both wheels O and P are, like wheel L, heavy and shrouded, and each contains 18 teeth. The heavy top crushing roller Q, on shaft R, is driven by contact with rollers K and M, and it is between these three ponderous rollers, K, M, and Q, that the heads of jute are crushed and opened, as well as partially softened.

The two ends of the roller shaft R are encircled by guide blocks S, which keep the roller Q vertical as the guides rise and fall in the slots in the framework. The slight vertical movement of roller Q is due naturally to the varying thickness of the heads. The combined weight of roller Q and shaft R is 15 to 18 cwt., and this load is often sufficiently great to obtain the degree of crushing desired. Extra pressure may, however, be obtained, if occasion demands, by the addition of one or more weights U, of 20 lb. each, on each rod T, the ends of which are fixed to guide blocks S. Sometimes the extra pressure is obtained by means of strong spiral springs. In the plan view Fig. 33 one side of the framework is shown complete, while the other side of the framework and part of the top crushing roller Q appear in section. With a pulley speed of 150 revs. per min., and the wheels given, the speed of the two bottom crushing rollers K and M is as under.—

$$150 \times \frac{15}{50} \times \frac{11}{57} = 8{\cdot}68 \text{ revs. per min.},$$

giving a peripheral speed of the rollers equivalent to—

$$\frac{8{\cdot}68 \times 12 \text{ in.} \times 3{\cdot}14}{12 \text{ in. per foot}} = 27\tfrac{1}{4} \text{ ft. per min.}$$

The bale opener is driven from shaft 32 in Fig. 28; and since this shaft runs at 180 revs. per min., and the pulley A on the machine is 24 in. in diameter, the drum on the shaft will require to be 20 in. in diameter. Thus—

$$150 \times \frac{24}{x} = 180.$$

$$x = \frac{150 \times 24}{180}$$

$$x = 20 \text{ in.}$$

The travelling cloths for both feed and delivery are driven by wheel gearing on the driving side of the machine (see Fig. 33).

The feed cloth travels a little slower than the peripheral speed of rollers K and M, whereas the delivery cloth travels a little faster than the latter. Wheel V on the shaft J, through carrier wheel W, drives the wheel X on the front feed roller shaft Y; and since the feed cloth Z passes over both cloth rollers 2 and 3, and is made to move in the direction of the arrow, and between the side guides 4, the heads of jute are carried towards and placed between the crushing rollers. Similar wheels 5, 6, and 7 drive the delivery

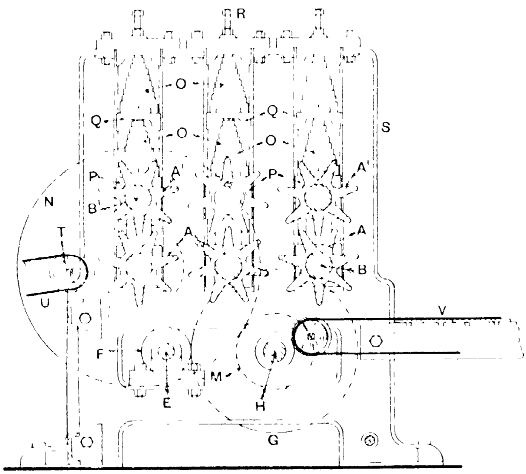


FIG. 36.

roller shaft 8, and the delivery cloth 9 passes similarly over rollers 10 and 11 and between side guides 12.

Assuming that one bale of jute contains heads or layers the aggregate length of which is 56 ft., it is evident that with a delivery speed of 26 ft. per min. the production will be approximately one bale in two minutes. In actual work the machine may be in operation for only part of each day, but when continuously employed it is possible to pass 1000 to 1200 bales through one machine in a week. As a rule, however, the men who attend the machine

also bring the bales from the store, and under such conditions the production from the machine is from 500 to 600 bales per week

Another typical bale opener also largely used in the jute trade is that type made by Messrs. Urquhart, Lindsay & Co. Limited, Dundee, and by Messrs Lee, Croll & Co , Lawside Foundry, Dundee Figs. 34 to 36 are illustrative of the machine made by the former firm, and they indicate respectively an end elevation of the driving side, a plan, and a sectional elevation of the interior of the machine This bale opener consists essentially of powerful top and bottom crushing rollers A^1 and A, Fig 36, each containing seven flutes, and supported by heavy shafts B^1 and B, three pairs of rollers are invariably employed The usual method of driving is by means of fast and loose pulleys C and D on shaft E, which may run at 80 revs per min. This shaft extends through the machine, and at the side opposite to that of the driving pulleys carries a pinion F of 20 teeth which gears with and drives large wheel G of 68 teeth on shaft H Compounded with wheel G, or at least fixed on the same shaft H, is an intermediate pinion J of 20 teeth The teeth of pinion J are wide enough, as shown in the plan view, to drive the fluted roller wheels K and L of 60 teeth each on the second and third shafts B counting from the left hand In some cases two ordinary pinions are used, one for each wheel K and L, instead of one with wide teeth On the opposite end of shaft H is keyed a pinion M of 33 teeth, which drives the large wheel N of 99 teeth on the first roller shaft B It will thus be seen that with the driving pulley rotating clockwise, as indicated by the arrows, all the three lower shafts B will rotate in the same direction, and it will also be observed that all three shafts are driven positively by heavy gearing If the main driving shaft or pulley shaft be driven at 80 revs. per min., each shaft B of the fluted rollers will make 7·84 revs. per min

$$\text{Revs. per min.} \times \frac{F}{G} \times \frac{J}{K} = \text{revs per min of roller shaft},$$

or

$$\text{Revs per min} \times \frac{F}{G} \times \frac{J}{L} = \text{revs per min. of roller shaft.}$$

Numerically as per values of wheels above—

$$80 \times \frac{20}{68} \times \frac{20}{60} = 7{\cdot}84 \text{ revs per min. for second and third shafts},$$

and

$$\text{Revs. per min.} \times \frac{F}{G} \times \frac{M}{N},$$

or

$$80 \times \frac{20}{68} \times \frac{33}{99} = 7\cdot84 \text{ revs. per min. for first shaft;}$$

while the peripheral speed of the fluted rollers, which are $13\frac{3}{8}$ in. in diameter, will be

$$\frac{7\cdot84 \text{ revs.} \times 13\frac{3}{8} \times 3\cdot1416}{12 \text{ in. per foot}} = 27\cdot45 \text{ ft. per min.}$$

It will of course be understood that the line followed by the fibre will coincide to some extent with the outline of the flutes, and that in consequence the actual speed will differ from the above peripheral speed. The same remarks hold good for the machine illustrated in Figs. 29 to 33. The actual production in both machines is about the same.

There is a clearance of about $1\frac{1}{4}$ in. between the roots of the flutes of one set of rollers and the tips of the flutes in the other set of rollers, so that no damage can be done to the fibre. The blocks of the top row of fluted rollers A^1 are forced down by means of powerful volute springs O in pairs. The bottom springs rest upon the sliding blocks P of the upper roller shafts B^1, while the top springs are guided in their limited up-and-down movements by slides Q, the upper parts of the springs come in contact with lock-nuts and bolts R, and these provide facilities for regulating to some extent the degree of pressure outside that which obtains in virtue of the weight of the rollers themselves. The whole mechanism is supported by a very substantial frame S.

The usual rollers T are provided for the feed sheet U upon which the heads of jute are placed as mentioned and illustrated in connection with the other machine. The heads of jute are then drawn in by the first pair of fluted rollers, and then successively through the second and third pairs to be ultimately deposited on the delivery sheet V, which is kept in motion by the two rollers W. The two sets of rollers for the feed and delivery sheets are driven in the proper direction by suitable wheels, some of which are illustrated at X and Y respectively, while the material is prevented from falling off the feed and delivery sheets by the usual guides Z.

Another and somewhat unique type of bale opener is that made by Messrs. Scott Brothers, Tayport, from Finlayson's design; the novel principle introduced appears to be quite suitable for practical purposes if the machine is fed judiciously. Fig. 37 illustrates the driving side and the delivery end of the machine, while Fig. 38 shows the opposite side, the feed end with the bales in position, and

FIG. 37.

a general view of the department. As will be seen from the latter view, the two upper rollers are situated in oblique slots, each roller having the usual bottom roller.

The bottom roller of each pair is about 11 in. diameter, while the diameter of each of the two upper rollers is about 17 in. All are deeply V-fluted, and the top rollers are driven by contact with the bottom ones. The bottom rollers are positively driven by wheel-gearing in much the same way as are those in the two machines

already described and illustrated; there is this difference, however: the bottom roller near the feed side in the machine under consideration is driven more quickly than the bottom roller near the delivery side; this difference in speed is the chief feature of the machine and is adopted to obtain the effect claimed by the designer.

A wheel of 52 teeth on the shaft of the bottom roller near the feed side is driven by a pinion of 11 teeth, while a similar pinion of 11 teeth drives a wheel of 68 teeth on the shaft of the bottom roller

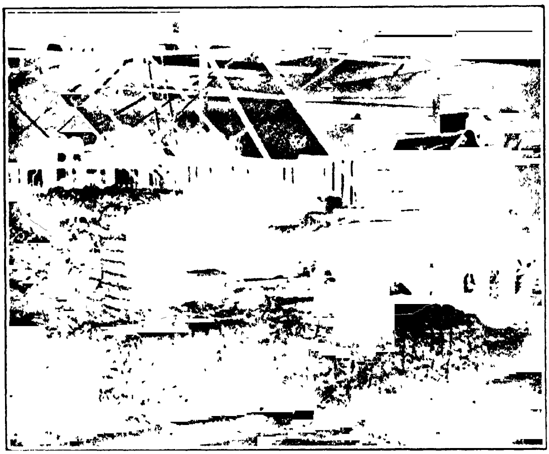


FIG. 38.

near the delivery side. Hence, if the pulley rotates at 50 revs. per min., we should have—

$$50 \times \frac{11}{52} = \frac{550}{52} = 10{\cdot}6 \text{ revs. per min. of the feed roller,}$$

and

$$50 \times \frac{11}{68} = \frac{550}{68} = 8{\cdot}1 \text{ revs. per min. of the delivery roller.}$$

The first impression one gets from such an arrangement is that the fibre would collect between the two pairs of rollers and thus choke the machine. In practice, however, the heads of jute pass substantially straight through the first pair of rollers, but more or

less sinuously through the second pan, and, as already mentioned, satisfactory results are obtained provided that the feeding is comparatively uniform. As a matter of fact, the feeding should be uniform in all machines for the breaking of jute.

Volute springs are used partly to supplement the weight of the roller for pressure, and partly as a flexible point in case of heavy feeding. One of these springs is shown on one of the horizontal parts of the framework in Fig. 37.

Although the above three general types of machines are those which are almost invariably used for jute-bale opening or jute crushing, the steam hammer is still used in some places for the same purpose, while in others heavy sledge hammers are used. The original method of opening was performed by taking each head in turn, and striking it against the others, literally using one head as a hammer to soften the others, or else by striking each head on the floor. This was in the days when less pressure was applied in the packing or baling, and consequently the heads were not nearly so hard and so compact as they are now. It will be understood that bale opening as described above is necessary only for jute which has been firmly packed by hydraulic presses. The jute which is delivered to the Indian mills is in a comparatively loose state, in drums or kutcha bales, and hence the above operation is unnecessary. When the bale opener is used, it is usual to collect the material as it issues from the delivery sheet, and to place it on suitable stools or stillage preparatory to being opened and divided into streaks or stricks of a suitable size for the subsequent operations.

Uniformity in colour is, as already mentioned, one of the valuable properties of jute, and not the least important, and if great differences in colour obtain, the dark and light shades are sometimes placed in different piles on the above-mentioned stools. The production of a high-class yarn depends partly upon the colour, partly upon the quality of the fibre, and partly upon the way in which the various operations are conducted. There is perhaps no department in a mill where greater attention should be paid to the material than in the batching department. Apart altogether from the defects which might arise from an imperfect or unsuitable selection or combination of various marks, there is the possibility of hindrance consequent upon the inefficient handling of the fibre

between the bale opener and the softener. Indeed, the successful manipulation of the jute depends largely upon the regularity of the stricks, which are made up by an operative termed a "striker-up," after the fibre has been delivered from the bale opener and before it is fed in to the softening machine. Years of experience have proved conclusively that the successful treatment of jute is accomplished by the addition of water and oil to the fibre at some stage before the latter leaves the batching department. The particular time or place when or where these liquids should be added is a matter of opinion, but stated generally we may say that in hand-batching the liquids are usually added before the fibre reaches the softener, whereas in machine-batching they are added during the time that the fibre is passing through the softener. In both cases it is clear that the stricks will be moistened most uniformly when they are all uniform in size or thickness, and when such conditions obtain the subsequent operations proceed more smoothly than they would if the moisture or lubrication were not uniform. The irregularity in the thickness of the stricks may not be very serious in hand-batching, because it is usual to allow the moistened jute to lie much longer in the batch stalls or barrows than when the fibre is machine-batched, but in machine-batching, where in many cases the amount of liquid depends somewhat upon the thickness of the strick, uniformity in thickness is very desirable, and absolutely essential if the subsequent operations are to be conducted in the most satisfactory method.

HAND-BATCHING.—The selected bales for the batch in hand-batching are brought from the store into the batching department and placed on their ends somewhat as depicted in Fig. 38, or preferably leaned against some suitable support in front of what is termed a batching stall or batching barrow. These stalls are usually fixtures, and if there is plenty of room available in the batching department, and all the stalls arranged within easy access of the softening machine—the next machine in the process—the arrangement is quite satisfactory. On the other hand, the movable stalls, such as those illustrated in Fig. 39, facilitate the work considerably, for it is evident that special and convenient places may be set apart solely for the actual work of filling the stalls; the full stalls may then be wheeled into the most convenient positions for the jute to mature,

and then taken to the feed end of the softening machines. In Figs. 39 and 40 the columns of the shed form a suitable base for supports for the bales to rest against, and that part of the shed on the right of the columns in the former view is reserved exclusively for the filling of the stalls. Two or three groups of filled stalls, six in each group, appear on the left of the columns, and the jute in these stalls is maturing It is quite evident from the illustration that a large floor space is required in order that the work may be conducted in the best possible manner.

It will be noticed that when this system is practised the bale opener may be dispensed with. Two men usually work at one

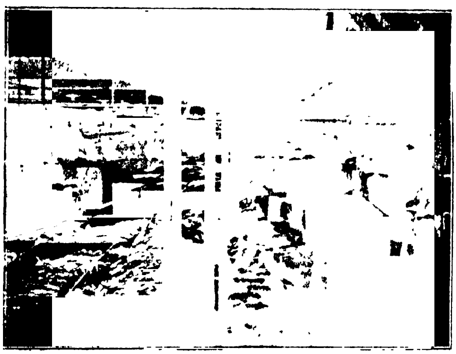


FIG. 39

stall, and, after they have cut off the ropes from the bales and removed the bale marks, they proceed to loosen the heads of jute by means of a large hammer. The heads of jute are opened out and separated into convenient pieces termed "stricks," and deftly doubled with a slight twist before being placed in the stall. The stall itself may be made of any desired size so far as the height and width are concerned, but the depth from front to back must naturally be sufficiently great to accommodate the length of the doubled strick. The interior dimensions of the stalls illustrated in Fig. 39 are 12 ft. from end to end, 5 ft. 6 in. from top to bottom, and 4 ft from front to back. Each stall can hold comfortably seven bales of jute of 400 lb. each, or 2800 lb. The date of filling the stall, the

time of day when the filling is started, and the quality of the batc are all distinctly noted on the end of the stall as illustrated Fig. 40, which affords a capital idea of the way in which the wo: is carried out. One complete layer of stricks is shown at the botto of the stall, and it requires 20 of these layers to fill it. Each lay when completed is moistened with half a gallon of oil from tl perforated spout of the one-gallon oil-can shown in the figure, ai then the hosepipe, which at present is seen against the front colum is unhooked from its support, and water is freely sprayed from t long perforated spout. The application of oil and water is repeat

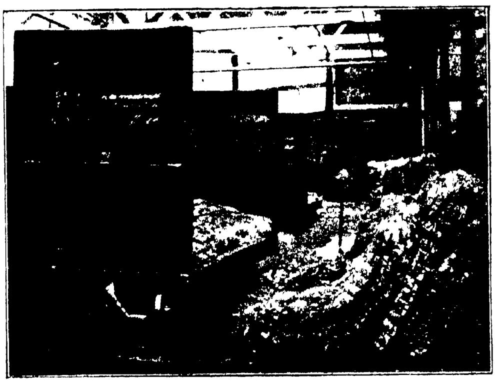


FIG. 40

every layer, and Fig. 41 shows clearly the convenient way in whi the work is performed. In this figure the stall is nearly full– small quantity of the seven bales only remaining on the flo The small pieces of cloth with the bale marks printed thereon a shown to the left in the foreground of the illustration.

In some cases the men get on to the top of the jute when t stall is about half full and tramp the jute down; the operation repeated when the full quantity of jute has been introduced. Tl helps the oil and water to penetrate more rapidly into the hea: of the stricks, and when the stall is filled it is an advantage to co the jute with a damp cloth, and to place two or three planks the top to impart a slight pressure. This method is particula:

advantageous in summer months when the moisture from the jute is liable to evaporate quickly. The jute is then allowed to remain for about 48 hours so that the liquids may moisten the material uniformly—this is termed maturing the fibre

In every case there is a fixed amount of oil distributed over the layers, but it is quite evident that the uniform distribution of the oil by pouring out by hand and swinging the can from end to end depends entirely upon the skill or care exercised by the operative A careful workman will distribute the oil pretty evenly, and each section will probably receive an average amount, but unless care

FIG 41

is exercised, uneven oiling must result The same remarks apply to the distribution of the water, but in this case the liquid is not measured and the batcher has more freedom In some batching departments both the oil and the water are heated. In other places the two liquids are made into an emulsion by the addition of an alkali and a common soap.

We have already mentioned the fact that the fibre is always passed through what is termed a softener or softening machine, whether it is hand-batched or machine-batched. These machines are heavy in build, and require about 2 h p. per section of 8 pairs of rollers. Figs. 42 and 43 show respectively an elevation and a plan of part of a softener as made by Messrs Urquhart, Lindsay

& Co. Limited, Dundee. The machines are built up of sections, each section containing 8 pairs of rollers, the last pair near the delivery end are different from the remainder. A complete machine of the ordinary size contains 63 pairs of rollers or 8 sections, but three sections only are illustrated in the figures: one to illustrate the feed end, another the section upon which the batching apparatus is fixed, and the third the delivery section. In some cases 79 pairs of rollers are placed in one machine. The fast-and loose pulleys A and B are placed as usual on the main driving shaft C, which extends as shown across the machine. Two small bevel-wheels D, one on each side, gear with larger bevel-wheels E on the ends of the two side-shafts F. Each side-shaft F drives half of the bottom fluted rollers G by means of bevel-wheels H and J, the driving wheels being arranged on the two sides alternately. The bottom rollers are made with a long end and a short end, as shown in the enlarged detached figure near the bottom of Fig. 43, the bevel-wheels J are naturally fixed on the long end, and this arrangement enables the rollers to be inserted for the alternate method of driving.

The fibre is fed in at the left on to an endless feed-sheet K, shown only in Fig. 42; this sheet travels over wooden rollers L and M, the upper layer naturally travelling in the direction of the arrow, and carrying the several stricks of jute towards and between the first pair of rollers M. The bottom roller only of this pair is shown. The rollers M deliver the fibre to the first pair of iron rollers N, see Fig. 43, with straight flutes. The lower wooden roller M is driven from roller N by means of wheels O, P, and Q; wheel P is, of course, introduced to make roller M travel in the same direction as roller N and all the rollers G.

The softening rollers G are in pairs as shown in Fig. 42, and the flutes of both rollers in each and every pair, with the exception of the first and last pairs, are arranged spirally as illustrated in the large detached figure in Fig. 43. The flutes in the rollers run from left to right in, say, the odd rollers, and from right to left in the even rollers. The top rollers of four pairs in Fig. 43 are drawn with the flutes as arranged in practice. This arrangement has a tendency to keep the fibre moving parallel to the side frames. The rollers, neglecting the ends, are 2 ft. 8 in. wide, and the number of

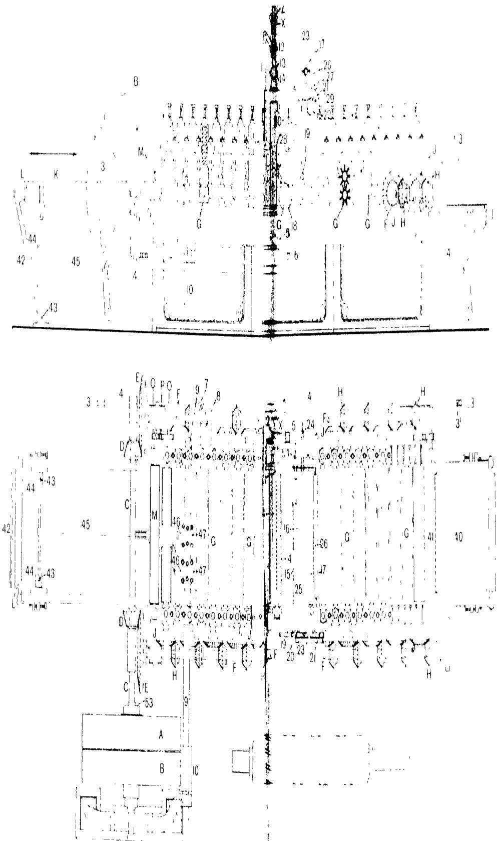


Fig. 1

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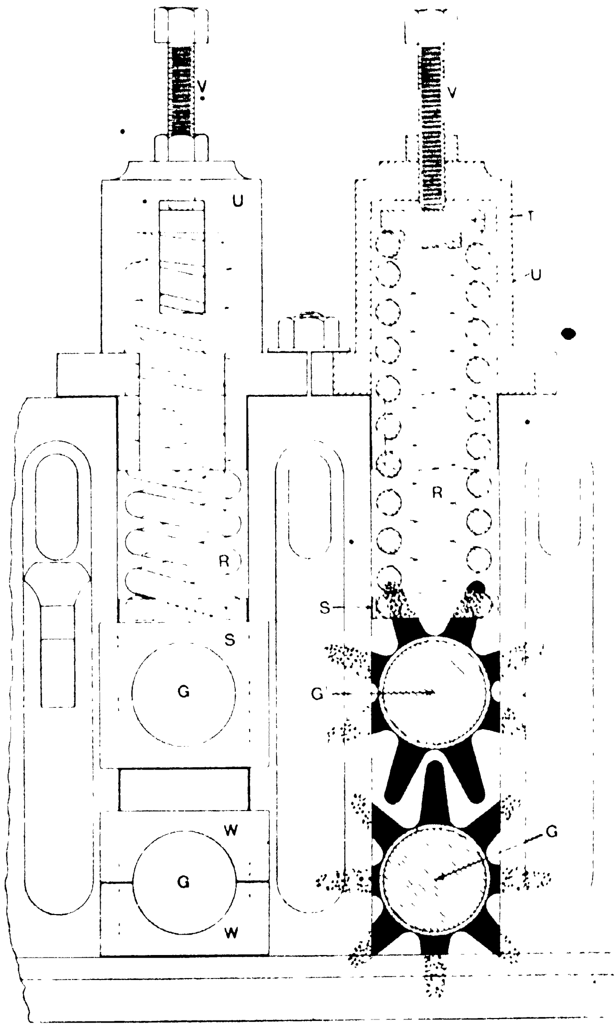

FIG. 44.

flutes in each roller varies from 8 to 13. The last three rollers in Fig. 43 are shown in their bushes, and the method of driving roller 41 is identical with that adopted for driving roller M. The general arrangement of each pair is illustrated on a larger scale in Fig. 44, the left-hand pair representing an exterior view of all parts, while the right-hand pair is a section through the middle of the spring R. The lower part of spring R rests upon the upper surface of block S, and is kept in position by two parts of a concentric ring cast upon the block S. The edges of the upper plate T rest upon the spring R, and the major part of the latter is enclosed in the bell-shaped bracket U. Two such brackets are supplied for each pair of rollers, one at each end. The degree of tension is regulated by the screw V, which is in close contact with the upper surface of plate T. The underside of the latter fits inside the spring, and it is so constructed that it can be easily removed from the bell-shaped bracket without removing the latter from its position.

Block S is in one piece, and it supports the shaft of roller G^1. It also rests upon the upper half of block W, which supports the shaft of roller G. When the block S is in its lowest position—that is, when there is no fibre between the rollers G and G^1—the clearance between the tips of the flutes of one roller and the roots of the companion roller is about $\frac{1}{8}$ in., and the spring R always tends to keep the upper roller G^1 in its lowest position. The positive drive of the lower roller G naturally rotates the upper roller G^1, and the spring R yields to allow the fibre to pass between. Most of the rollers in Fig. 42 are represented simply by circles, but it will be understood that, with the exception of one pair at each end, all are of the same shape, and are practically identical with the single pair shown in solid black in Fig. 42 and Fig 44.

After the fibre has passed through a certain number of pairs of rollers, the oil lubrication is mechanically and automatically dropped on to it from the batching apparatus illustrated in the middle section of Figs. 42 and 43. We have placed the apparatus in its present position partly because it very often occupies this position, and partly in order to simplify the drawing and to keep the apparatus distinct from the feed and delivery sections. The actual position of the apparatus is quite an arbitrary one, but in the above figures it occupies a convenient position for being driven by the

twelfth pair of rollers. It is the upper roller of this pair which regulates the supply of oil to the fibre, while the lower roller of the same pair, in conjunction with its connecting wheel gearing, shuts off and starts the supply. The usual method of lubrication in machine-batching is to apply the water first, and the oil immediately afterwards, and the following is a description of the double operation. The rate of flow of the water is determined by a valve X and handle Y. A pointer on handle Y and a graduated plate Z enable the operative who is responsible for this task to fix the rate of flow for any particular class of jute. When once the flow of water is fixed, the handle Y is kept opposite the same mark on graduated plate Z, and a constant quantity is thus assured. The water has to pass through a second valve 12, but this valve is opened and closed respectively by the starting and stopping of the machine. Attached to the set-on handle 3 at the feed end and the set-on handle 3^1 at the delivery end is a rod 4 which extends the full length of the machine as shown, and the movement of this rod will clearly alter the positions of the arms of bell-crank lever 5, Fig. 42, fulcrumed at 6. Another bell-crank lever 7, Fig. 43, fulcrumed at 8, is attached at one end to rod 4, and at the other end to bar 9, to which is fixed the belt fork 10. When either set-on handle 3 or 3^1 is moved to the right, both bell-crank levers 7 and 5 are partially rotated; the former through its connections places the belt on the fast pulley A, and the latter draws down rod 11, Fig. 42, and thus opens valve 12 to allow the water to flow downwards. It is essential that the water should be distributed over the full width of the rollers G, and different methods are employed to achieve this desirable condition. The water may issue from the valve 12 into a channel, box, or pipe the full width of the rollers. In the figures the water flows into pipe 13, and the overflow from this pipe—*i. e.*, from the holes or slot at the top of the pipe—flows downwards to the V-shaped points of the plates 14. In some cases the water drops direct from these points on to the upper rollers and on to the fibre as the latter is passing through the machine. The chief point to watch with regard to the water is that a sufficient or maximum supply should always be available; a different method, however, is necessary for the oil which is applied immediately afterwards.

The general idea of the mechanism for the distribution of the oil is to regulate the amount by the thickness of the fibrous material which is at the moment passing between the pair of rollers connected to the oil supply. The thicker the strick of jute the more oil should be liberated, and *vice versa*. The oil is kept at a constant height in the tank 15, Fig. 43, by means of a valve 54 and float 16; a roller 17 is continually rotating in the oil when the machine is in operation by a train of wheels from the end of the lower roller G of the twelfth pair. These wheels are represented by circles in Fig. 42, and their numbers and value are as follows: Wheel 18 of 50 teeth, wheel 19 of 118 teeth, wheel 20 of 50 teeth, compound wheel and pinion 21 and 22 of 70 teeth and 30 teeth respectively, and roller wheel 23 of 105 teeth. If the main driving shaft C revolves at 140 revs. per min., the speed of each roller G will be—

$$\text{Revs. of shaft C} \times \frac{D}{E} \times \frac{H}{J} = \text{revs. per min. of roller G},$$

or

$$140 \times \frac{18}{40} \times \frac{16}{25} = 40 \text{ revs. of roller G};$$

and the speed of the oil roller 17 will be determined by wheels 18, 21, 22, and 23, since wheels 19 and 20 simply convey the motion from wheel 18 to wheel 21. Thus—

$$(\text{Revs. of roller G}) \; 40 \times \frac{50}{70} \times \frac{30}{105} = 8{\cdot}16 \text{ revs. per min. of wheel 23 and oil roller 17.}$$

Wheel 22 is the change pinion, and the speed of the oil roller 17 may be increased or decreased by a larger or smaller pinion 22.

The oil is kept heated by means of steam which enters through valve 24 into the steampipe 25. This pipe is sometimes in the form of a steam coil, while at other times two or three lengths of straight pipes pass through the oil tank. The amount of oil which is drawn up by the roller 17 is approximately constant, but the amount which is delivered to the fibre depends, as already mentioned, upon the position of the upper roller G¹ with respect to the lower roller G. A brass plate 26 with a saw-like edge at the bottom and a straight edge at the top is so placed that its straight edge is parallel to the oil roller 17, and is capable of being moved nearer

to or farther from the roller 17 by means of arm 27 and rod 28, both of which are fulcrumed at 29. The lower end of rod 28 is bent, and rests against a boss on the shaft of roller G^1 As the roller rises in virtue of the thickness of the material, rod 28 drops slightly by gravitation, and the upper edge of plate 26 is moved nearer to oil roller 17, and thus removes an increased amount of oil from the roller. This increased quantity of oil reaches the rollers G and G^1 immediately under plate 26 at the same time as the material which caused the excess of oil to be taken from roller 17 by plate 26. When no fibre is passing through the machine, the roller G^1 is in its lowest position, and the curved end of rod 28 in its highest position; at this time the upper edge of plate 26 is farthest removed from the oil roller 17, and sufficiently far from it to allow the oil on the oil roller to miss the plate When the fibre enters the rollers, the rod 28 is dropped approximately proportional to the thickness of the fibre, and simultaneously the edge of plate 26 is forced nearer to the oil roller 17. It will be clear that when the edge of the plate 26 is very near to the roller 17, the oil is, as it were, scraped off the roller by the plate, and the oil flows over the surface of the plate until it reaches the lower saw-edge, from which it drops as described above.

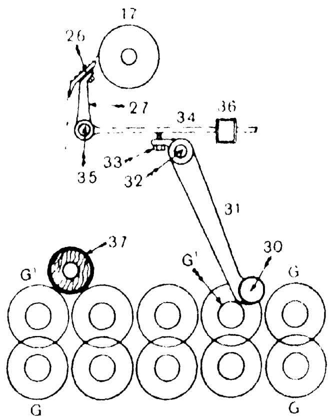

FIG. 45.

Another and perhaps better method of regulating the supply of oil is illustrated in Fig 45. Five pairs of rollers are represented by the intersecting circles G and G^1. Resting by gravity against the arbor or boss of one of the upper rollers G^1 is the weighted end 30 of lever 31 fulcrumed at 32. A set-screw 33 passes through a hole in a lug cast on the upper end of lever 32, and the end of this set-screw supports weighted lever 34 fulcrumed at 35. The position

of lever 34 obviously determines the position of arm 27, and therefore that of the plate 26. When the upper roller G^1 is raised, ball 30 is raised and set-screw 33 descends through a short distance; the weight 36 causes lever 34 to accompany set-screw 33, and thus the edge of plate 26 is carried into closer proximity to roller 17 in order that it may remove more oil from roller 17. The simple arrangement of a set-screw provides means for obtaining as fine an adjustment as appears possible under the present conditions. It has already been mentioned that the oil may drop on to the rollers G^1 and on the fibre, but it is a better plan to place a wooden roller 37 on the top of two rollers G^1. This roller 37 is covered with two or three layers of felt somewhat similar to and often exactly the same as that used for feed sheets, and the oil drops, as shown, on to the felt. Most of the oil is absorbed by the felt, and as the roller 37 is carried round by rollers G^1 the oil is pressed out and deposited on the fibre

There is one drawback to the efficient working of this apparatus and all similar ones. The movement of the plate 26 is determined by the up-and-down movements of one end of roller G^1, and this movement is clearly influenced most by the thickness of the fibre near the end where the motion is fixed. If uneven feeding obtains, it is quite possible for thick parts to be near one end of roller G^1, and thin parts near the other end, but the amount of oil which is distributed will be practically uniform over all the width. Consequently, although the quantity delivered may be correct for one end, it may be too little or too much for the other end. Nevertheless, faulty as the application may be, the distribution of the oil is more uniform than it would be without such regulating apparatus; and if the feeding is anything like uniform, which it usually is, the arrangement is very satisfactory.

Occasionally two oil rollers are connected by suitable gearing to the same roller G^1, but these oil rollers run at different speeds. The speeds are approximately 7·84 and 2 revs. per min. These speeds are on the assumption that rollers G^1 make 40 revs. per min. The gearing for the oil roller nearest the feed end with the resulting speed is as under:—

$$40 \times \frac{50 \times 63 \times 91}{118 \times 105 \times 118} = 7{\cdot}84 \text{ revs. per min.};$$

while the corresponding particulars for the second oil roller are—

$$40 \times \frac{50 \times 63 \times 50 \times 29}{118 \times 105 \times 70 \times 105} = 2{\cdot}006 \text{ revs. per min.}$$

In other batching departments the application of the oil is on a much simpler plan, and the method is almost identical with that of applying water. For instance, two valves are used, one to admit the proper amount, and the other to shut off the supply when the machine is stopped, as well as to allow the oil to flow at a constant rate when the machine is in motion. The second valve is connected to a pipe somewhat similar to that illustrated in Fig. 46. This pipe has a long slot 38, which is at the top of the pipe when the latter is in its position. The oil overflows through this slot at a constant rate, runs down the several grooves 39, and ultimately drops on to the roller 37 in Fig. 45. This arrangement forms a very simple

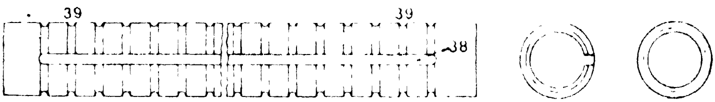

FIG. 46.

and efficient method of applying both oil and water, and is extensively adopted.

Returning again to Figs. 42 and 43, it will be seen that after the fibre reaches the end of the machine it will be deposited on the delivery sheet 40 by the last pair of rollers 41. In many machines both feed rollers M and delivery rollers 41 are practically the same. The feed sheet 40 invariably passes round the roller immediately under 41, and the pair of rollers just in front of 41 are straight-fluted. In general, rollers M and 41 are simply wooden rollers similar to 41, the last pair of rollers G and G¹ are straight-fluted, and the first pair N are usually spirally fluted, although we have shown them straight.

Figs. 47 and 48 are end views of the same machine viewed respectively from the feed end and the delivery end, but with the feed sheet and the delivery sheet removed. The general arrangement of the oil and water pipes is seen best in these views. The machine is very heavy and well built, and it is quite evident that

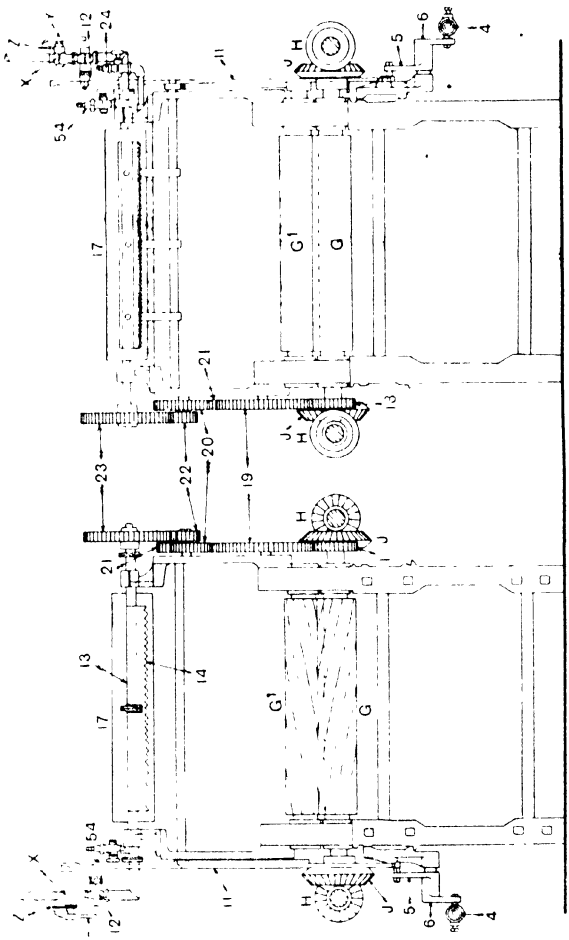

FIG. 48.

FIG. 47.

when once the rollers G and G[1] grip the fibre, the latter is bound to go forward. Originally the feed sheet was a comparatively short one, and on rare occasions the feeding operatives have had the misfortune to be drawn into the machine, with disastrous results. Such unfortunate occurrences are now impossible if the machine

FIG. 49.

is fitted with the best known type of automatic stop-motion (Williamson's patent), and the long feeding table as illustrated in Figs. 42 and 43, and more in detail in Figs. 49, 50, and 51. Referring first to Figs. 42 and 43, it will be seen that a lever 42, fulcrumed

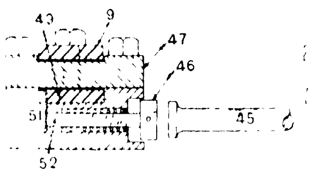

FIG. 50.

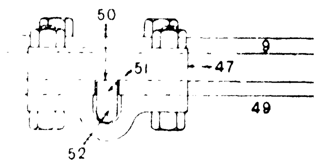

FIG. 51.

at 43, rises practically to the same height as the feed sheet roller L. The upper end of lever 42 is concave to correspond with the convexity of roller L. The operative stands behind the lever 42, which is shown in the inoperative position, and he deftly throws the stricks of fibre, thin end first, on to the feed sheet which carries the stricks to the rollers. If by any chance the fibre became entangled with any part of the operative, the attendant would be

drawn towards the feed-sheet roller L, but immediately he came into contact with the upper end of lever 42 the latter would clearly be pushed forward, and the projecting arm 44 would cause rod 45 to move forward until the end of rod 45 came into contact with the head 46 of bracket 47. When this happens the belt is forced on to the loose pulley by the heavy spiral spring 48, and the machine is stopped before the attendant is injured. In Fig. 43 the bracket 47 is shown in two positions—the "on" position being dotted immediately opposite rod 45, and the "off" position in solid. When the set-on handle is moved to the "on" position, the belt fork 10 draws the belt on to the fast pulley A, and the rod 9, as well as bracket 47, moves in unison until bracket 47 occupies the dotted position opposite the pushing-off rod 45. All these parts move together and in perfect unison when starting or stopping the machine in the ordinary manner; it is only in cases of emergency that the parts are separated to prevent an accident. When the lever 42 is forced forwards under such circumstances as mentioned, that part attached to the belt fork is moved to the "off" position, and the set-on handle remains stationary in the "on" position. The nature of the movement will be better understood by reference to Figs. 50 and 51, where the end of rod 45 is shown in close proximity to the corresponding head 46 of bracket 47. The rod 9 extends right across the machine as illustrated in Fig. 49. The lower rod 49 moves with rod 9 when all is working right. The connection between the two bars is completed by a notch 50 in bar 49, into which fits the head 51 of pin 52. If, however, rod 45 comes against the head 46 of pin 52, the opposite head 51 is forced out of the notch 50 in bar 49; when this happens, the powerful compressed spring 48 on bar 49, Fig. 49, carries the belt fork to the "off" position, and thus stops the machine independently of the movement of rod 9 and the set-on handle 3.

The machine, like all others of a similar nature, is liable to get choked with the material, and to provide for such contingencies a pitch or shear pin 53 is introduced into the driving pulley Fig. 43. This pin gives way before any serious damage can happen to the machine.

In practically all softening machines for machine-batching an arrangement somewhat similar to one of those described is used,

but when the fibre is hand-batched such apparatus is evidently not required on the softener. Thus in Fig. 52 a softener is shown without the batching apparatus, simply because the fibre has already been batched, as will be seen by the presence of the two large stalls immediately behind the feed sheet. This machine is practically of the same structure as that illustrated in Figs. 42 and 43. It is the type usually made by Messrs. Charles Parker, Sons & Co., Dundee, and is naturally arranged to take the batching apparatus when required. The main drive of all these machines may be as shown in Figs. 42 and 43, or, if space is a consideration, the drive may be suited to circumstances. Thus, in Fig. 52 the belt-and-

FIG. 52

pulley shaft is an additional one placed parallel to the long sides of the machine. In other cases this additional shaft is vertical. The particular method of driving is, however, of little moment; in every case the chief parts of the machines are practically identical.

(The man at the feed end in Fig. 52 is just in the act of throwing the fibre on to the feed sheet, while at the delivery end of the machine the sheet of softened fibres is seen emerging from the straight fluted rollers on to the delivery sheet, from which it is taken by the attendant and placed on the scales until the desired amount, or what is termed the "dollop bundle," is obtained.) The bundle of softened fibre is then tied up, removed from the scales, and deposited on the floor preparatory to being taken to the back of

the breaker card. Several of such bundles appear on the floor near the scales, while a similar bundle is easily seen in the figure immediately behind that on the scale, but on the stool adjoining the feed sheet of the breaker card.

It is almost impossible to discuss with any reasonable degree of success the relative merits of the two distinct methods of batching, as the success of either depends so much upon environment. The mechanical method, while still of a simple nature, can be arranged to perform the work quite accurately, and its almost universal adoption is sufficient proof of its adaptability to varying requirements. The softening machines as already described, in conjunction with either of the methods mentioned of applying the requisite amount of water and oil to the jute, are in general use, the method of performing the operation is quite simple, and with a fairly intelligent set of operatives may conduce to results which are quite satisfactory.

The operative who removes the jute from the delivery sheet of the bale opener, see Figs. 29 to 38, either places the heads of jute in a pile or delivers them directly to the "strikers-up." There are usually four strikers-up required to prepare the jute for the softening machine, and under these conditions about 260 bales of jute are batched per week of 48 hours by each softener. The duty of the striker-up is to split up the heads of jute into pieces of a convenient size, not only for the batching, but also for the subsequent process of carding. A piece or strick of good jute, 7 to 8 ft. long, should weigh from 2 to 2½ lb., in order that the above-mentioned 260 bales per week can be batched by one softener. Owing, however, to the great difference in the lengths of the various heads of jute, it is impossible to fix upon a definite weight per piece to secure accurate batching and preparing. Nevertheless, it need not be a difficult matter to make the stricks equal in bulk or thickness whatever their lengths happen to be. Thus, if we take the strick mentioned above as a necessary or reasonable standard of thickness to secure the desired production, it would be correct to make all other stricks of the same thickness, irrespective of the length or the weight for a similar production. Indeed, it must be an absolute rule that all the stricks supplied to the softening machine shall be of a uniform thickness. In some cases it is considered advisable to employ one

feeder who supplies the material in a single row, strick after strick, to the feed sheet; at other times two rows are supplied by two feeders, and this latter number is necessary for the production of 260 bales per week by each softener.

The stricks of jute moistened by the water and oil are removed from the delivery sheet of the softener by operatives termed "twisters"; one twister only is required if the machine is fed in a single row by one feeder. The twister grips the strick about midway between its ends, and by a quick movement of his hands gives a partial twist to the strick, and then deftly throws it on to a barrow which is placed in a convenient position near the end of the machine

Fig. 53

The barrows used for machine-batching are very much smaller than those already described for hand-batching; the former are only 6 ft. long, about 5 ft. high at the ends, and 4½ ft. wide, and they hold from 3 to 4 bales according to the method of building the stricks on the barrow. One method of filling the barrow is illustrated in Fig. 53, in which it will be seen that the twisted parts or central portions of the stricks overhang the edges of the barrow. The stricks are built alternately from the two sides of the barrow, so that the roots and the tops overlap each other, layer after layer. The roots and tops being completely covered up, the process of what is termed "heating-up" is encouraged; this process loosens the small portions of roots and softens the hard ends, which are seldom

Fig. 54.

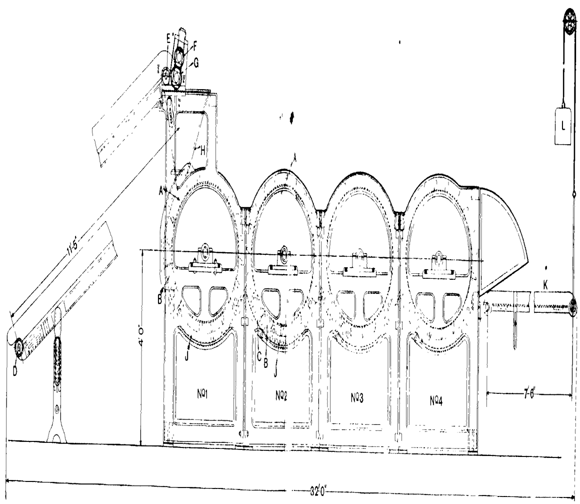

Fig. 55.

[To face page 81.

cleaned off except in the very best class of fibre. After the barrows have been filled as illustrated, they are stored in the most convenient place for a period of 24 or 48 hours.

Bale cuttings and special grades of jute may require different treatment to any of those already described. The cuttings are usually baled before they are quite dry indeed, in a rather moist condition; they are packed very hard in the bale, and hence are difficult to separate.

There are two methods of treating such cuttings One method is to open out or separate the material by means of a steam hammer or some such satisfactory mechanical apparatus, and to pass it direct to the bale opener and softener, a more recent method of treatment is to pass the material through what is known as a "root opener"—a machine patented by Mr. Orr, of Messrs James F. Low & Co Limited, Monifieth Fig. 54 is an illustration of the driving side of this machine, while Fig 55 is an elevation, the dotted parts of which show the internal structure of the mechanism, while the solid parts represent the framework at the side opposite to the driving. In both views it will be seen that there are four distinct and strongly built cylinders of the same size, and marked No. 1 to No. 4. These cylinders, which measure 33½ in. diameter over the staves, are provided with a number of heavy steel pins A, and as the cylinders rotate, these pins pass between similar rows of stationary pins B fixed in the breast-plate. The jute cuttings are laid on the travelling feed-sheet, which rotates on rollers D and E, they are thus carried upwards, and ultimately enter between the fluted feed-rollers F and G, and then into the hopper H. When the cuttings reach the bottom of the hopper they are gripped by the rotating teeth A of No. 1 cylinder, and during their passage they are rubbed, as it were, between the fixed and moving pins B and A. This rubbing action loosens the fibres, and at the same time removes the dirt and sand, which will fall between the bars J of the cages or grids on to the floor or into suitable receptacles. There is naturally a grid underneath each cylinder.

The cuttings should be fed evenly on the feed-sheet in order that the work may be done efficiently and with the least wear and tear on the various parts of the machine. Overcrowding and irregular feeding result in inferior work, and are detrimental to the

machine. With ordinary and even feeding the machine is capable of opening and cleaning sufficient cuttings to keep one softening machine employed. It will be understood that the cuttings pass forward through all the four sections, and then pass on to the delivery table K, and finally on to the feed-sheet of the softener. This direct feeding to the softening machine minimises labour, and should always be adopted when conditions permit. If, however, the softener is required at intermittent periods to work long jute, the delivery table K of the root opener can be raised by means of the weight L, and thus leave room for the operative to feed the softener in the usual manner.

The hard ends of the cuttings are split up, and the material opened and cleaned when it reaches the feed-sheet of the softener; it is thus in an ideal condition to receive the water and oil as it passes through the softening machine. When cuttings are lubricated with the roots unopened the effect is not so beneficial, for there is more work to be done by the pins of the breaker card, and, in addition, part of the lubricating liquid may escape with the dirt and sand. The operations of batching and softening are carried out as described in machine-batching; the only difference is that the cuttings are allowed to lie in the batch for about a week to mature.

The other method of treating the cuttings can be carried out in any convenient place. The bales are laid on the ground, all the ropes are cut off, after which two lengths of rope are tied loosely round the bale—one near each end. A heavy iron bar is then used to slacken the various heads in the hard bale, and about four gallons of boiling water are poured on; the bale is then turned through 180° and other four gallons of boiling water poured on to it. After this treatment the bales may be built on the top of each other, each layer being arranged to allow sufficient room for expansion; this expansion always takes place during the time, say two to five days, that they are left to slacken.

When the time arrives for these cuttings to be included in a batch the material is conveyed to the bale opener, where precisely the same operations are performed as in the case of long jute. It will of course be understood that since each bale receives eight gallons of water during the above process, a smaller quantity will be necessary in the batching process. The foregoing is typical of a common

method of treatment, but various modifications may be made to suit existing conditions in any particular mill.

The application of water and oil to the jute fibre is rendered necessary by its chemical and physical composition. Unlike flax, which is composed of an oily or pecto-cellulose, the jute fibre is known as a bastose or ligno-cellulose. Both flax and jute fibres, however, may be termed compound fibres when compared with cotton and wool, which are simple, or rather single, fibres. The jute fibre as it is used is in reality a filament composed of bundles of fine fibres, or ultimate fibres, which are held together by some cementing material. For investigation purposes Cross and Bevan divide the vegetable fibres into two distinct groups based upon the composition of this cementing material, and defined broadly as—

(*a*) Pecto-cellulose, of which flax is the type, and
(*b*) Ligno-cellulose, of which jute is the type

It is this ligneous or woody matter which causes the dry nature of the jute fibre, and which necessitates the use of water and oil as lubricants in the batching process. The addition of a suitable lubricant to the fibres facilitates their uniform and free movements through the subsequent preparing machines.

Various kinds of oil have been found quite suitable for batching; consequently, the use of any particular kind is very often influenced greatly by its cost relative to that of the others. Three distinct classes of oils are in general use, and these may be used either alone or in mixtures of two or more kinds These classes are—

1. Animal or fish oils: Whale oil; seal oil; oils refined from fish refuse at fishing ports and sold as fish oil or herring oil, recovered grease from wool fibres and fabrics.
2. Vegetable oils: Linseed oil, cottonseed oil, palm oil.
3. Mineral oils: Of these there are several kinds, the best known being Broxburn, Pumpherston, Oakbank, Young, and American.

As already mentioned, soaps and saponifying ingredients are sometimes added so that the oils and water may be mixed and then applied to the fibre in one solution. In addition, deliquescent and antiseptic agents, such as magnesium chloride, calcium chloride, sodium fluo-silicate, and zinc chloride, are used. The latter is extensively used, but it should be free from iron.

The undermentioned are a few typical mixtures of oils for batching :—

1. For good-class warp and weft yarns	Whale oil	$\frac{4}{10}$
	Seal oil	$\frac{3}{10}$
	Mineral oil (0·900 to 0·907 s.g.)	$\frac{3}{10}$
2. For medium-class yarn	Whale or seal oil	$\frac{4}{10}$
	Wool-oil grease	$\frac{1}{10}$
	Fish or herring oil	$\frac{1}{10}$
	Mineral oil (0·890 s.g.)	$\frac{4}{10}$
3. Lower-grade wefts	Fish oil	$\frac{4}{10}$
	Palm oil	$\frac{1}{10}$
	Mineral oil	$\frac{5}{10}$
	Black soap 1 to 2 per cent.	
4. Sacking weft	Mineral oil (0·885 to 0·900 s.g.), depending upon the quality of jute used.	

When arranging the various oils for the mixture for any class of yarn, it is advisable to keep in mind the following points: Vegetable oils are sometimes cheaper than fish oils, but owing to their tendency to overheat in the batch they must be used with caution. There is also a tendency in these oils, if used alone, to stick to the pins and rollers. The lower grades of mineral oils, if used alone, have a hardening effect on the fibre, besides lowering the colour of fine jute. Owing to this hardening effect there is an increased amount of waste of fibre at the various machines. These types of oils, however, keep the machinery in good condition by preventing the adhesion of dust and dirt to the pins, etc.; for this reason it is advisable to have a proportion of mineral oil in all mixtures.

The oils are usually mixed in a tank capable of holding about 100 gallons, and this tank is often enclosed in a larger tank provided with water. The water may be heated by a steam coil or from the discharge pipe of a condensing engine. Whatever method is adopted, it is very desirable that the oil should be heated so that it may be applied to the jute at a temperature of not over 200° F. Lower-grade oils often vaporise at 205° F., and it is highly essential that vaporisation should be prevented. If the water and oil are mixed to form one solution, it is an advantage to boil the mixture, and in both cases it is beneficial to provide the tank with an agitator, so that the constituents with different specific gravities which form the mixture may be thoroughly blended; such an arrangement

also prevents a sediment, for it keeps all the constituents in suspension. Perhaps the chief advantage of using a saponified mixture is the fact that more accurate proportions of water and oil can be obtained than is possible when the two liquids are applied separately; a more uniform distribution might therefore be expected.

A very convenient method of storing the oils at the mill is to arrange the tanks so that they may receive the oil direct from the tank carts. When oil is supplied in tank carts the price is 10s. per ton less than if it is supplied in 40 gal. barrels. Pumps may then be arranged to fill the batching-house tanks or mixing tanks, and the latter may be connected to the pipes at the softener. Another method is to provide small tanks to contain a certain quantity of oil, and to fix them immediately above the distributing apparatus.

The quantity of oil per bale depends partly upon the fibre and yarn, but mostly upon the kind of oil, and it varies from 1 to 2½ gals. of oil per bale of 400 lb., together with 6 or 7 gals. of water. The best coloured oil and the smallest quantity should be used on the best qualities of jute, while the lower-quality oils in greater quantities may be used for the commoner-class yarns. The construction of the mill and the atmospheric conditions which prevail at the time will regulate to some extent the amount of water to be used; but it may be taken as a sound rule that whatever quantity of water is used, it should not be so excessive as to cause any trouble in the various operations. On the other hand, there need be no hesitation in using as much oil as is required to help the various operations, because it all remains in the fibre and in the yarn, whereas the bulk of the water evaporates during the time that the material is progressing through the various departments.

A series of tests with reference to the evaporation of oil was made by the authors on a class of fibre on which the largest proportion of oil was a good-class mineral oil. The mixture really contained 90 per cent. of mineral oil (0·890 to 0·895 sp. gr.), and 10 per cent. of seal oil. No water was used. To a given weight of fibre was added 15 per cent. of this oil mixture. The lubricated fibre was then spun into yarn in the usual way, packed in a hessian wrapper, carefully weighed, and stored in such a way that any loss in weight would be quickly seen. The bale was weighed every

month from February to November; the greatest loss was in July, and was a little over 1 per cent., but in November the bale weighed exactly its original weight.

There are, perhaps, difficulties in the way of securing uniformity of conditions, but efforts should be made to achieve this desirable state, and thus obtain the best results. It is always a good plan to be able to make at least a rough test of the oils for comparison with regard to colour, specific gravity, and fluidity. Glass vessels of the same diameter, and made from the same quality and thickness of glass, should be used for the colour test. The specific gravity is naturally tested by a hydrometer, and at a temperature of 60° F. The same temperature should obtain when testing for fluidity with a viscometer. The latter is usually a glass bulb with a capacity of 100 c.c., and provided with an opening through which this volume of water can flow in a definite time—not less than 30 or 60 secs. The viscosity of oils with reference to water can then be found, and the short-time bulb or long-time bulb will be used according to the nature of the oils to be tested. It would also be an advantage to be able to test the flash-point of the oils used, but this is rarely done by the user, as it is considered sufficient to take the figures supplied by the oil refiners.

A typical example of the record of tests made may be useful as a guide in such cases :—

Date of Delivery.	Class of Oil	Supplied by	Temp. F.	Viscosity.		Specific Gravity	Flash Point.
				Mins.	Secs.		
15–8–14	Whale	Greenbank Whale Fishing Co	61°	5	30	0·916	500°
20–8–14	Mineral	Standard Oil Co.	60°	3	25	0·891	350°

An extremely important point in connection with jute is the condition of the fibre when it arrives in the manufacturing centre. It is too late to deal with the cause at this period, but faults or defects in the fibre which can be eliminated must be dealt with in the batching house previous to carding. Most of the defects are due to one or more of the following: Unsuitable seeds in the first

case; imperfect retting and cleaning; the haste exercised in marketing the fibre; and to the condition in which the fibre is baled.

Chaudhury gives the following glossary of Indian terms as applied to the jute fibre:—

Ashmara: Weak stuff.
Batch Pat: Fibre from immature plants rejected at the time of thinning.
Bukchhal: Barky portion of the fibre at some middle places, due to plants being allowed to grow after inundation and the water has subsided.
Croppy: Fibre having rough and hard top ends.
Fui Fibre of superior quality
Flabby: Wanting in firmness—loose
Ful Pat: Immature stuff cut before flowering This fibre is excellent in colour, but somewhat weak and gummy
Knotty. Full of knots. Knot is a portion of fibre agglutinated which resists separation, mainly due to an insect bite or puncture on the growing plant.
Mossy. The lowland swamped jute with numerous adventitious roots (or extraneous vegetable matter).
Rooty: The jute is called by this name if from the lower part of the fibre the gum and bark are not wholly removed, and in which the fibres stick together.
Specky: Containing patches of outer bark here and there.
Sticky: With pieces of stick or pith amongst the fibre (usually in small plants from the Daisee district).

The eight small samples in Fig. 56 illustrate some of the faults enumerated above; the fibres were selected by Mr. George Stewart in the Naokhali district during the jute-retting season.—

1. Lamjore jute. The best quality of early jute.
2. Bidyasunder: Fine jute grown on high lands
3. Typical sample of stained fibre due to sand and mud; also Agehal or crop end.
4. Jute grown near the sea and discoloured by dirty steeping water.
5. Second quality early jute. short length
6. Weedings which must be purchased to get the good-quality fine fibre.
7. Coarse fibre due to want of water for steeping.
8. Mestha fibre: Quite good colour.

These faults or defects may in part be remedied or dealt with in various ways—*e. g.*, (1) Weak fibre necessitates great care in mixing with the better-grade fibres, so that no great quantity may be allowed to collect at any point in the slivers. (2) Gummy fibre can only be helped by using more oil in the batching. (3) Sticky fibre can be greatly improved in the carding process. (4) Specky fibre may also be improved and partially cleaned by allowing the

jute to lie a little longer in the batch. (5) Croppy fibre, which comes only with early jute, may be cut off, but if the jute is kept in store for some time it improves considerably. (6) Knotty or barky fibre can only be cleaned by cutting. (7) Rooty fibre must either be cut off, or combed as explained further on.

In addition to the above defects, the jute may be damaged in

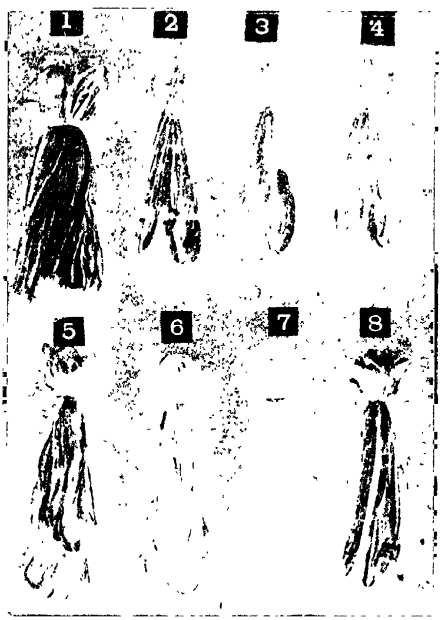

FIG. 56.

transit by bad ventilation in the holds of the ships; it may also deteriorate by long storage or "age.". On the other hand, new jute or early crop is usually harsh, and it lacks the spinning property of more mature kinds. Some difficulty is experienced in using the first arrivals immediately; nevertheless, the best fibre, both for quality and colour, is usually in the early shipments.

Excess moisture: In recent years a considerable amount of

trouble has resulted from the damp condition in which the jute was baled in India. This defect causes "heart damage," and serious loss and friction are caused to the trade from this source. We have already mentioned the fact that jute has a natural affinity for moisture, but it is necessary to see that this natural quantity of absorption is not increased by artificial methods, and various ways are employed to check the hygroscopic condition of the fibre. Thus, a bale of jute is sometimes opened out and exposed in this loose condition to the air, say, for 24 hours. The fibre, if comparatively dry, absorbs an amount of moisture which is influenced by the atmospheric conditions at the time; the moisture may then be dried out and a fair idea obtained of the probable loss, but a safer and more accurate method is required before both parties to the contract are satisfied.

Conditioning houses are used in a few of the mills for exhaustive tests of excess moisture. The whole of the material is dried perfectly, and then an allowance percentage regain is agreed upon. Other firms have small conditioning ovens in which a few pounds of jute may be tested quickly and accurately by heating to a temperature of 220° F. This temperature drives off all the moisture, and the fibre may then be allowed to regain naturally its normal percentage of moisture. Instead of submitting the fibre to the latter process of natural absorption, a regain allowance may be agreed upon.

In three tests made by the authors for the amount of moisture in jute fibre it was found that—

Sample	1	lost	9 oz	12½ drs	from	2 lb	9 oz.	12½ drs.
,,	2	,,	7 ,,	14 ,,	,,	2 ,,	14 ,,	13½ ,,
,,	3	,,	8 ,,	7½ ,,	,,	2 ,,	15 ,,	11 ,,

In most tests for conditioning—say, for wool, cotton, and silk—it is usual to give the percentage moisture on the original weight, and the percentage of excess moisture with respect to the absolute dry weight. If the above samples of jute were conditioned in this manner, and if it were agreed that jute in its normal or air-dry condition should be 13 per cent. heavier than the absolute dry fibre—*i. e.*, after the fibre has been heated to 220° F.—then Table A will give us the various particulars required for the above three samples:—

TABLE A

Number of Material.	Original Weight.	Absolute Dry Weight Heat Applied = 220° F.	Total Weight of Moisture	Per cent Moisture on Original Weight.	Percentages Reckoned on Absolute Dry Weight.			
					Per cent Moisture.	Weight with 13 per cent. Regain.	Weight of Excess Moisture.	Per cent. of Excess Moisture.
	lb. oz drs	lb oz drs	oz drs			lb oz drs.	oz drs	
1	2 9 12½ 668·5 drs.	2 0 0 512·0 drs	9 12½ 156·5 drs.	23·41	30·5	2 4 2½ 578·5 drs	5 10 90·0 drs.	15·56
2	2 14 13½ 749·5 drs.	2 6 15½ 623·5 drs.	7 14 126·0 drs.	18·85	20·21	2 12 0½ 704·5 drs	2 13 45·0 drs.	6·39
3	2 15 11 763·0 drs.	2 7 3½ 627·5 drs.	8 7½ 135·5 drs.	17·76	21·51	2 12 5 709·0 drs	3 6 54·0 drs.	7·62

TABLE B

Number of Material.	Original Weight.	Absolute Dry Weight Heat Applied = 220° F	Total Weight of Moisture.	Per cent. Moisture on Original Weight.	Percentages Reckoned on Air-dry Weight. 87 Parts Fibre, 13 Parts Moisture.			Actual Weight of Material After Two Days' Exposure.
					Air-dry Weight	Excess of Moisture	Per cent. of Excess Moisture	
	lb oz drs	lb oz drs	oz drs		lb oz drs	oz drs.		lb oz drs
1	2 9 12½ 668·5 drs	2 0 0 512·0 drs.	9 12½ 156·5 drs	23·41	2 4 12½ 588·5 drs.	5 0 80·0 drs	13·59	2 3 9 569·0 drs.
2	2 14 13½ 749·5 drs.	2 6 15½ 623·5 drs	7 14 126·0 drs.	18·85	2 12 12½ 716·5 drs 716·6 ,,	2 1 33·0 drs.	4·61	2 11 13 701·0 drs.
3	2 15 11 763·0 drs.	2 7 3½ 627·5 drs.	8 7½ 135·5 drs.	17·76	2 13 1½ 721·5 drs 721·3 ,,	2 9½ 41·5 drs.	5·75	2 11 14 702·0 drs.

If, on the other hand, the percentages are reckoned on the air-dry weight of the fibre, and if we assume that the material in this condition contains 87 parts of fibre and 13 parts of moisture, then Table B will apply.

The latter table is recommended as being the better, at any rate for jute, for the following reasons: In the first place, it is unnecessary to use percentages when concrete numbers can be obtained as quickly, for in nearly every case the calculation is extended if percentages are used. In the second case, all excess moisture leaves the fibre during the preparatory and spinning processes, but that amount which is present in the air-dry condition usually remains with the fibre and oil. Consequently, if once the actual proportions of fibre and moisture in the air-dry condition are found and acknowledged as standard values in any particular town or country—and these values will naturally vary in different places, and also at different times of the year in the same place—it would be possible not only to determine quickly the exact air-dry weight for the invoice value, but at the same time to compare the total quantity of air-dry fibre which enters the mill with the output of yarn over any given period. We need hardly say that when these particulars are available for the proprietor and manager they afford a capital check upon waste of every kind; for, neglecting the slight change in moisture which takes place from month to month, the output plus the waste should be approximately equal to the weight of the air-dry fibre delivered to the mill plus the weight of oil which has been consumed.

If for any particular reason the actual percentage of moisture in the material is given, it is just as easy to find the weight of the accepted air-dry condition. For example—

Let W = the total weight of the sample or bulk;

M = the total weight of moisture expelled at a temperature of 220° F.;

F = the percentage of absolute dry fibre in the accepted air-dry condition;

A = the air-dry weight.

Then—

$$\left(100 - \frac{100\,M}{W}\right) \times \frac{100}{F} \times \frac{W}{100} = A.$$

$$\frac{100\,W - 100\,M}{W} \times \frac{W}{F} = A.$$

$$\frac{100\,(W - M)}{F} = A.$$

Hence we have simply to introduce the difference between W and M, which is obviously the absolute dry weight, and divide by the percentage of fibre which has been accepted as the proper proportion obtaining in the air-dry state.

Amongst jute fibre experts it is generally considered that the value of F lies between 86 and 88, and we have therefore taken the mean, 87. This, of course, means that in every 100 lb. of naturally dried fibre there are 87 parts absolute dry fibre and 13 parts water.

Numerical example Suppose a nominally 400 lb. bale of jute, after having been heated until all the moisture is expelled, weighs 346¼ lb., what is the invoice value of the bale?

$$\frac{100\,(400 - 53\tfrac{3}{4})}{87} = A.$$

$$\frac{100 \times 346\tfrac{1}{4}}{87} = 397{\cdot}93 \text{ lb.}$$

and

$$397{\cdot}93 \times \frac{\text{average weight of bales}}{400} \times \text{number of bales in delivery}$$

$$= \text{the invoice weight in pounds of air-dry fibre.}$$

If a smaller quantity is tested, say in an ordinary conditioning oven, then the invoice value of any parcel of jute may be obtained as under :—

$$\frac{\text{Absolute dry weight of sample}}{\text{Original weight of sample}} \times \frac{100}{87} \times \text{original weight of parcel}$$

$$= \text{invoice weight of air-dry fibre.}$$

Example: A sample of jute weighing 1 lb. $7\frac{1}{2}$ oz. weighs, when heated to 220° F., 1 lb. 0 oz. 14 drs.; what is the invoice weight of air-dry material in 10,000 lb. (25 bales, each nominally 400 lb.)?

$$\frac{1\text{ lb. }0\text{ oz. }14\text{ drs.}}{1\text{ lb. }7\tfrac{1}{2}\text{ oz.}} \times \frac{100}{87} \times \frac{10,000}{1}$$

$$= \frac{270\text{ drs.}}{376\text{ drs.}} \times \frac{100}{87} \times \frac{10,000}{1} = 8254\text{ lb. approximately.}$$

CHAPTER V

INTERMEDIATE PROCESSES

THE root ends of the stricks of jute often require special treatment, and various methods are employed to deal with these roots. Cutting and snipping have been largely practised, particularly the former, and a root - combing machine has now been introduced. The most satisfactory economical conditions obtain when the whole, or practically the whole, of the jute fibre is utilised, and the above-mentioned root-comber is the most modern machine which has been introduced to fill up the cycle in order that this desirable state may be approached. The machine is the invention of Mr. Spence, and is made by Messrs. James F. Low & Co. Limited, Monifieth. It is illustrated in Figs. 57 to 61. The long lengths of jute A are spread over a travelling sheet B and just in front of the guard C of the three travelling chains D; see Fig. 58, which is a view of the driving side of the machine. The root ends of the fibre are exposed to view in this illustration, and are in close proximity to the plane of the points of the pins of the cylinder, which in this view rotates counter-clockwise. As the feed sheet B and the travelling chains D move forward slowly towards the machine, the lengths of jute are gripped in succession between the lower and upper sets of travelling chains D and E; see Figs. 57 to 59. The chains rotate as shown over grooved pulleys; the extreme upper and lower sets are shown at F and G in Fig. 57, and all in Figs. 58 and 59. Two shafts H and J, Fig. 60, which carry the chain pulleys near which the fibre A is delivered, are driven from the shaft K of cylinder L. The first wheel M on the shaft K is for communicating the rotary motion to the workers, etc. The shaft K is lengthened to carry wheel N of 40 teeth, which, with carrier wheel O and wheel P of 25 teeth, serves to drive the worm-shaft Q. Two double-threaded worms R and S

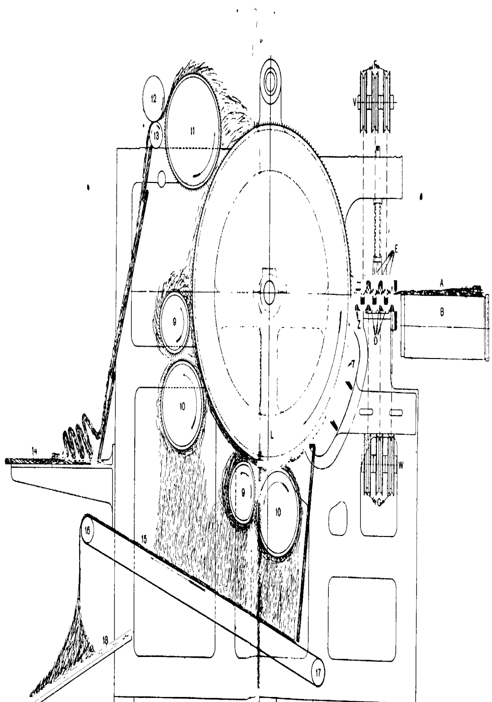

Fig 37

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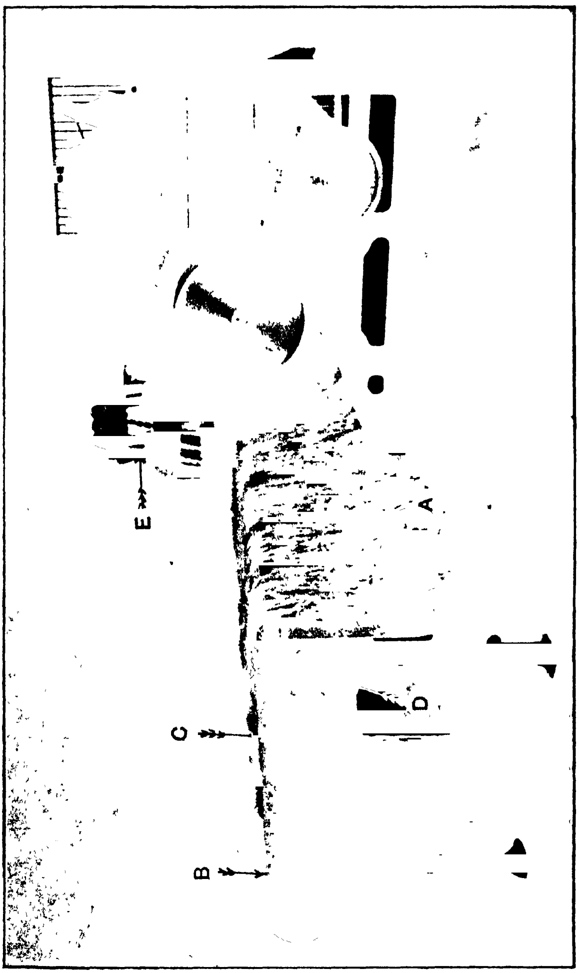


FIG 58

are secured to the shaft Q, and drive respectively the worm-wheels T and U, each with 31 teeth, the former being under the worm R and the latter over the worm S. The two wheels T and U thus move shafts H and J, and therefore the chain pulleys D and E in opposite directions. Similar chain pulleys, F and G, Fig. 57, running loosely on shafts V and W, are provided above and below those on shafts H and J, and also similar sets at the other side of the machine in order to provide means for a continuous rotation of the two sets of chains D and E.

The driving side of the chain pulley shafts H and J is illustrated in Fig. 59, which is, of course, opposite to the actual driving side illustrated in Fig. 58. These two views show well the disposition of the two sets of chains, and the dotted lines in Fig. 57 also represent the connections between the same parts

It will be seen that the movement of the fibre is across the front of the cylinder L, the surface of which is covered with pins, and that Figs. 58 and 59 show respectively the uncombed fibre entering the machine and the combed fibre leaving it. The difference in the appearance of the fibre in the two stages is quite apparent. Now it is evident that since the cylinder L rotates at about 165 revs. per min., it will be necessary to make provision for the free entry of the fibres in order that the pins of the cylinder may enter it perfectly, and perform the combing of the fibre without drawing the stricks bodily across the front of the machine. This provision is illustrated in Fig. 61. The upper part X of this figure represents one stave of 3¼ in. width and 6 ft. long in sections of 2 ft. each; the whole of the outer periphery of the cylinder L is covered with these staves. The middle part Y of Fig. 61 represents the same stave as X, but looking on the narrow edge, while the lower part Z represents the edge of the chain support. This support Z is continued downwards as shown in Fig. 57 to form the breastplate or shell 7. Returning to Fig. 61, the fibre enters on the right, and there is about 2½ in. clearance between the points of the teeth in section 1 and the outer part of the support Z. This gap gradually decreases for a distance of 3 ft. 9 in.—*i. e.*, to point 8, where it is only $\frac{1}{16}$ in. wide. The gap is constant for the remaining 2 ft. 9 in. Only one row of pins is illustrated at Y, but all are shown in the part X. It will be clearly seen that not only is the gap widest at

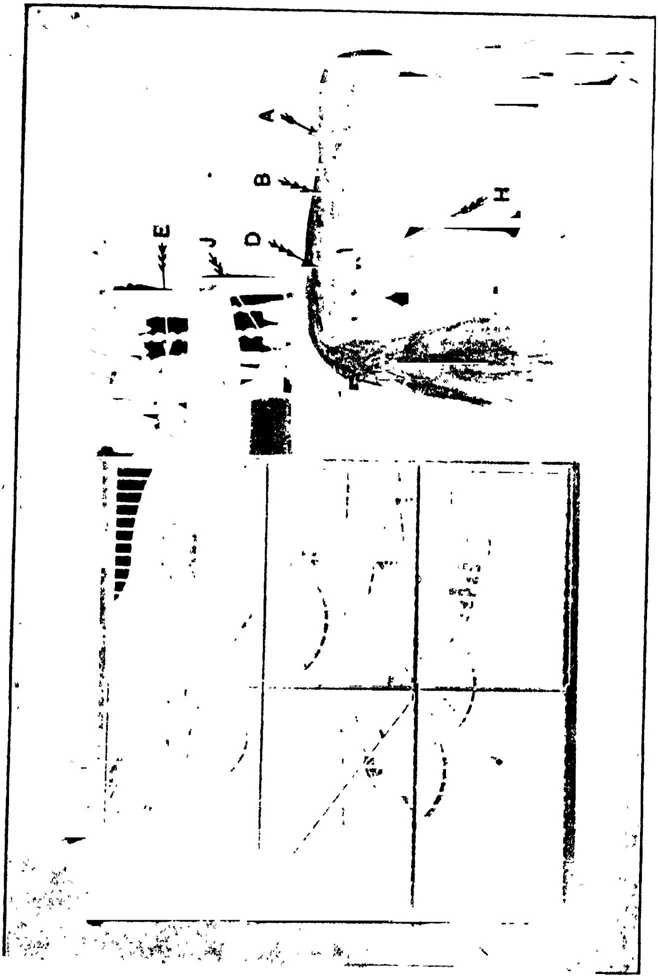


FIG. 59.

the entrance, but the teeth are heavy and coarsely pitched. They get finer and finer up to the last two sections, 5 and 6, in which

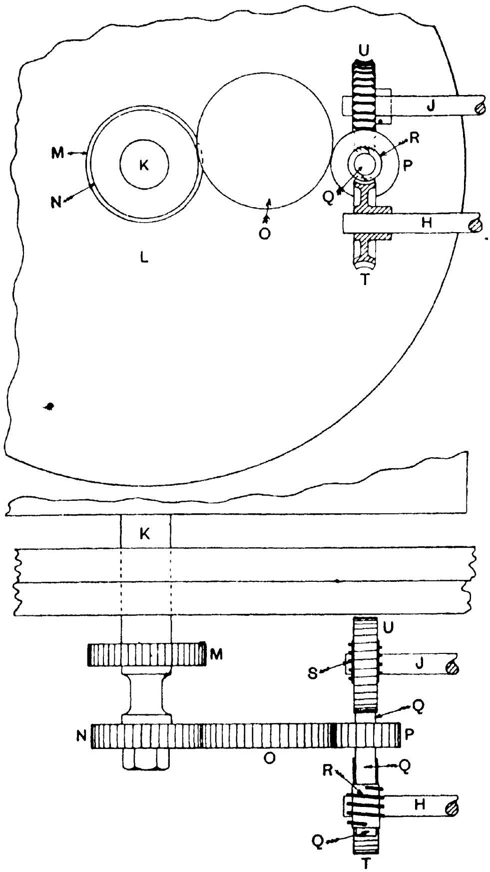


FIG. 60.

the pins are set to the same pitch. The particulars are as given on p. 99.

The first rough combing is done by the coarse teeth in section 1, and the gradually increasing fineness of the pins and pitch in successive sections up to No. 5 enables the work to be done efficiently and with a minimum amount of waste. All the time that the fibre is passing before the front of the cylinder L, those parts which are combed out are carried round by the pins to the two sets of workers 9 and strippers 10, and are then delivered in the form of a wide sheet by the doffer 11 and rollers 12 and 13. We have omitted the description of the actual functions of the cylinder, workers, strippers,

Section.	No of Rows	Horizontal Pitch in Inches	Wire Gauge
1	3	4	6
2	3	2	8
3	3	$1\frac{1}{2}$	9
4	3	$\frac{3}{4}$	10
5	6	$\frac{9}{16}$	12
6	6	$\frac{7}{16}$	12

doffer, and rollers, because these will be more conveniently described in connection with the breaker card. It is therefore sufficient for the moment to state that the stricks of fibres with their ends combed out perfectly are delivered as illustrated in Fig. 59; that the sheet of more or less carded fibre is delivered on to the table 14, Fig. 57; and that the roots, dirt, coarse fibre, small particles, etc., which are not carried round the machine completely, drop on to a travelling sheet 15, which rotates on rollers 16 and 17. This material is ultimately deposited on to the table 18 or on to the floor.

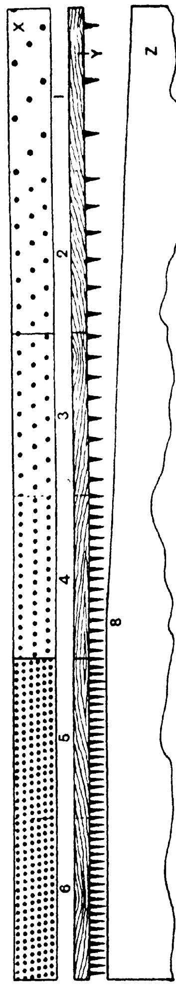


FIG. 61.

At least three men are required to work the machine—one to

lay the stricks of jute on the feed cloth B, the second to regulate the overlapping length for the purpose of exposing that part only which should be combed, and the third to remove the combed jute and to build it on a barrow ready for the breaker card or the weigher. The jute must, of course, be batched and softened before it enters the above machine, and it is very important that the pieces or stricks should be small enough not only for the breaker card, but also to enable the material to be combed efficiently in the root comber.

The best results appear to be obtained when the cylinder L has a speed of 165 to 175 revs. per min. With the former speed and the wheel gearing as given in connection with Fig. 60, we have—

$$165 \times \frac{40}{25} \times \frac{2}{31} = 17 \text{ revs. per min.}$$

of chain pulley and travelling sheet pulley.

$$17 \text{ revs.} \times 8{\cdot}5 \text{ in. pulley} \times 3{\cdot}1416 = 453{\cdot}96,$$

or 454 in. per min. of travelling sheet and chains.

$$\frac{454 \text{ in.} \times 600 \text{ mins.}}{36 \text{ in. per yard}} = 7566\tfrac{2}{3} \text{ yds.}$$

per day of ten hours. With the above speed the machine will comb the root ends of five tons of jute per day of ten hours.

A reasonable and fair average weight of stricks of jute may be taken at—

$2\frac{1}{2}$ lb. for a length of 9 ft., and
2 ,, ,, ,, ,, 7 ,,

The operative who regulates the length to be combed also spreads out the stricks, which we have stated should be uniform in thickness. To obtain the best result in combing, it is found that the strick should be spread over a width of about 30 in. Consequently, with $2\frac{1}{2}$ lb. for 30 in., or $2\frac{1}{2}$ ft. in width, we have 1 lb. of jute per foot of feed chain. Hence—

756 yds. per hour of chain × 3 ft. per yard = 2268 ft. and pounds of jute.

If from this we deduct 10 per cent. for stoppages, and also 10 per cent. for irregularity in feeding, we have—

$$2268 - \frac{20}{100} \text{ of } 2268\text{; or}$$

$$2268 - 454 \text{ nearly} = 1814 \text{ lb. per hour.}$$

Although the combing takes place only at the root end of the fibre, it is evident that the bulk of the weight per unit length is present here, and that a considerable reduction in the weight of each strick will result. If we assume that the weight of the strick is reduced during combing by 20 per cent. for good jute, and by 40 per cent. for poor jute—*i. e.*, an average of 30 per cent. over all—there would still remain

$$1814 - \frac{30}{100} \text{ of } 1814, \text{ or}$$

$$1814 - 544\cdot2 = \text{approximately } 1270 \text{ lb.}$$

of jute per hour ready for the breaker card.

FIG. 62

Two other methods of dealing with the root ends of jute are practised:—

(*a*) Snipping
(*b*) Cutting

Two types of machines are used for the former process, and Figs. 62 to 65 illustrate what is known in the trade as the "Butchart Snipper." Fig. 62 is a photographical reproduction of the machine, and shows the feed and delivery positions; Fig. 63 is an elevation of the driving end; Fig. 64 is an elevation of the opposite end; while Fig. 65 is a plan of the machine. Before describing the details

of the mechanism we might point out that the heads or stricks of jute in a loose form are separated from each other on the table to the left in the foreground of Fig. 62, and fed into the machine from this position. A second operative stands on the low stool or stillage immediately before the table to remove the stricks after they have been treated in the machine and delivered on the right near where the second operative stands. The long lengths of jute which are seen over the long rail in the view have been placed there to dry, and have nothing to do with the actual work of the machine.

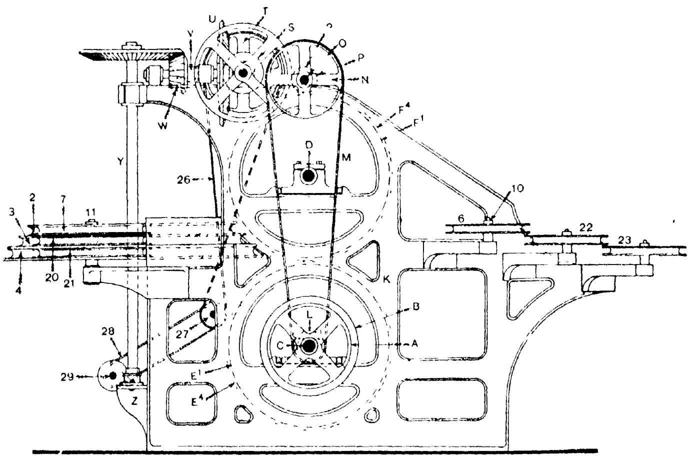


FIG. 63.

The loose pulley A, Fig. 63, and the flanged fast pulley B, each of 20 in. diameter, are situated on the low shaft C of the machine, while in the same vertical plane is a second shaft D. Shafts C and D carry the two cylinders E^1 to E^4 and F^1 to F^4 (see plan, Fig. 65, for the latter set). These cylinders perform a somewhat similar function to that performed by the various rollers in the root comber in Fig. 57. As will be clearly seen in Fig. 64, the upper cylinder F is driven from the lower cylinder E by a crossed belt G and the two flanged pulleys H and J, each about 18 in. in diameter. These parts constitute the whole of the mechanism which is required

for the actual combing process, which, however, always goes under the technical name of snipping.

Each cylinder, E and F, is made up of four sections, shown only in Fig. 65. The diameter of each section from the bottom of the illustration upwards is slightly less than that of the one immediately below; this difference in the various sections is for the same purpose as that described with respect to Fig. 61, p. 99, although this difference does not always exist. And for very similar reasons to those mentioned with respect to Fig. 61, the number of pins per

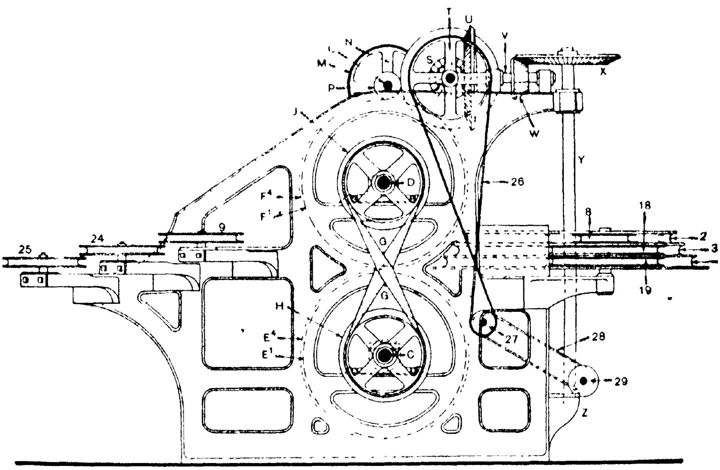


FIG. 64.

unit area varies in different parts of the width of the cylinders. The following particulars refer to the clothing or covering in the four sections:—

In section F^1 the staves are 3 in. broad; there is one row of pins, and the latter are 2 in. apart.

In section F^2 the staves are $3\frac{3}{4}$ in. broad, and there are three rows of pins in each stave. In the first half width the pins are 1 in. apart, while in the second half width they are $\frac{3}{4}$ in. apart.

In section F^3 the staves are $3\frac{3}{4}$ in. broad but rather thinner,

and there are again three rows of pins in each stave; but three different settings obtain in each stave. For one-third of the width the pins are $\frac{5}{8}$ in. apart; for the next third they are $\frac{3}{8}$ in. apart; and for the last third they are $\frac{5}{16}$ in. apart.

In section F^4 the staves are similar to those in F^3. There are four rows of pins in each stave, and the setting is uniform—$\frac{1}{4}$ in. separating each pair.

The points of the pins in section F^1 are about $\frac{1}{2}$ in. from the points of the pins in the corresponding section E^1 of the other

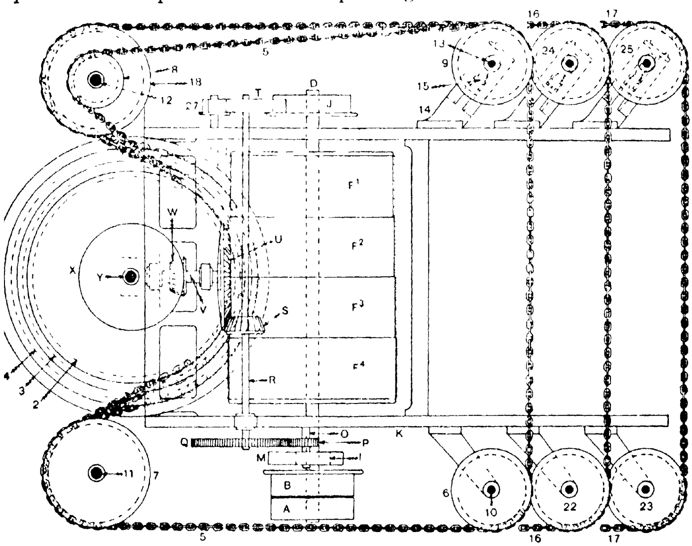


FIG. 65.

cylinder, while the points of the two sets of pins in sections F^4 and E^4 almost touch each other. The pins in sections E^2 and F^2 and in E^3 and F^3 are intermediate between those of the two extremes. Both cylinders revolve at approximately 160 revs. per min.

The covering for snippers may differ according to requirements, and according to the opinions of mill managers, but the main principles are usually observed. In some of the most modern productions the particulars of the cylinders and covering are as indicated in the accompanying table.

Section Lettered and Numbered.	Number of Staves in Section.	Diameter of Cylinder Without Clothing.	Diameter of Cylinder Over Points of Pins.	Length of Wood Staves.	No. of Wire Gauge.	Length of Pin.	Number of Rows of Pins.	Pitch of Pins in Width of Stave	Number of Pins per Row.	Pitch of Pins in Length of Stave.	Thickness of Wood Stave.	Pins Grouped In
F[1]	38	36 in	$38\frac{3}{4}$ in	$14\frac{3}{4}$ in	9's	$1\frac{3}{8}$ in	1	3 in	First half of stave 2 and 3 pins in alternate staves Second half of stave 5 pins	First half 3 in Second half $1\frac{1}{2}$ in	$\frac{7}{8}$ in	2
F[2]	30	36 in	$38\frac{3}{4}$ in	$14\frac{3}{4}$ in	10's 12's	$1\frac{3}{8}$ in	3	$1\frac{1}{16}$ in	First half of stave 7 pins Second half of stave 12 pins	First half 1 in Second half $\frac{5}{8}$ in	$\frac{7}{8}$ in	3
F[3]	30	$36\frac{1}{2}$ in	$38\frac{3}{4}$ in.	$14\frac{3}{4}$ in.	14's		10	$\frac{3}{8}$ in	First third of stave 8 pins.	First third $\frac{5}{8}$ in		10
					14's	$1\frac{1}{8}$ in	10	$\frac{3}{8}$ in	Second third of stave 14 pins	Second third $\frac{3}{8}$ in.	$\frac{3}{4}$ in.	10
					16's		15	$\frac{1}{4}$ in.	Third third of stave 20 pins	Third third $\frac{1}{4}$ in		10
F[4]	30	37 in	$38\frac{3}{4}$ in.	$14\frac{3}{4}$ in	18's	$\frac{7}{8}$ in.	20	$\frac{9}{16}$ in.	80	$\frac{3}{16}$ in	$\frac{9}{16}$ in	10

NOTE.—All the pins are set straight—i.e., perpendicular to tangential line.

A more extended mechanical arrangement is required for feeding the stricks into the machine, and for delivering them after they have been combed. Between the fast pulley B and the frame K, Figs. 63 and 65, is a small pulley L of 6 in. diameter, and from this pulley an open belt M passes to an 18 in. diameter pulley N, keyed to a sleeve or socket on the stud O. A pinion P, of 35 teeth, is also fixed on the sleeve of stud O, and this pinion gears with the wheel Q of 144 teeth on the shaft R. The shaft R passes across the machine, and on it are keyed a small bevel pinion S of 18 teeth and a belt pulley T of 18 in. diameter. The bevel pinion S gears with the bevel wheel U of 64 teeth, and thus drives the short shaft V and a second bevel pinion W of 18 teeth. The latter ultimately gears with bevel wheel X of 64 teeth, and consequently drives the upright shaft Y—the lower end of which is supported by a footstep in bracket Z, Fig. 63, and around which is placed a cover to keep the lubrication free from foreign matter of all kinds.

At a convenient place on the upright shaft Y are keyed three large grooved chain pulleys, 2, 3, and 4. Three endless chains, one for each pulley, are placed in the grooves of pulleys 2, 3, and 4, and also in similar but rather smaller grooves in a series of tension and guide pulleys. Thus, the top chain 5 passes partially round the top grooved pulley 2, guide pulleys 6, 7, and 8, and tension pulley 9. The grooved pulleys 6, 7, and 8 simply rotate, as their names indicate, on their studs 10, 11, and 12; and so does grooved pulley 2 on the shaft Y. Grooved pulley 9, however, not only rotates as desired on its stud 13, but is also capable of moving nearer to or farther from the inner end of the slot in its supporting bracket 14 according to requirements. A strong volute spring 15, Fig. 65, is situated between the rear end of the bracket 14 and the slide, and projecting upward from the latter is the stud 13; hence the slide and stud 13, together with the adjustable grooved pulley 9, is forced outwards until the chain 5 is perfectly taut. In precisely the same manner the chains 16 and 17 form adjustable endless chains on their respective pulleys; chain 16 passes into the grooves of pulleys 3, 18, 20, 22, and 24, while chain 17 passes into the grooves of pulleys 4, 19, 21, 23, and 25. In Fig. 62 the three chains are shown distinctly in the grooves of what we have numbered 7 and the two immediately under—the guard having been removed

purposely to obtain this view. The illustration also shows the three chains at the feed side of the machine between the pulleys 2, 3, and 4 and the pulleys 8 and 18. In this case, however, the guard is shown in position.

Returning again to the line drawings, it will be observed that a crossed belt 26 connects pulley T and a small pulley 27 of 5 in. diameter. Finally, an endless cloth 28 receives its motion from roller 27, while the latter and a similar roller 29 enable the cloth to perform its function in the usual manner.

The routine of the operation is somewhat as follows: The strick of jute is thrown over the grooved pulleys 2, 3, and 4 on the left side of the machine in Fig. 62, and in such a way that the root ends hang comparatively low as indicated. Immediately the upper end of the strick is caught between the three chains and the three grooved pulleys, it is carried into the machine; simultaneously the lower part of the strick, having already alighted on the travelling sheet 28, is also carried forward. The surface speed of the travelling sheet 28 is much greater than the circumferential speed of the grooved pulleys, and hence the lower end of the strick is carried before the remainder. This is naturally the condition desired, for this quick movement of the feed sheet 28 causes the ends of the strick to be entered or thrown between the parts E^1 and F^1 of the two cylinders, Figs. 63, 64, and 65, and the combing starts immediately between the coarsely pitched teeth in the above parts E^1 and F^1. The further rotation of the shaft Y and the three grooved pulleys 2, 3, and 4 carry the stricks farther round to place the root ends successively into contact with the parts F_2, F_3, and F_4, and the corresponding parts of the lower cylinder. The stricks finally emerge from the control of the three chains and the three grooved pulleys, when they are removed by the second operative, who places them on one side ready for the breaker card. The tow and the combed-out roots drop to the floor, from which they are collected intermittently, packed up in bags, and then taken to a suitable card for further treatment.

The following particulars will show the relative speeds of the essential parts of the machine :—

1. The combing cylinders E and F. These obviously make the

same number of revolutions per minute as the main shaft, which we have already stated is usually 160 revs. per min. Assuming that the average diameter of each cylinder is 3 ft. 3 in., the circumferential or surface speed will be—

$$160 \times d\,\pi = 160 \times 3{\cdot}25 \times 3{\cdot}1416 = 1633{\cdot}63 \text{ ft. per min.}$$

2. The speed of the grooved pulley shaft Y.

$$\text{Revs. of C} \times \frac{L}{N} \times \frac{P}{Q} \times \frac{S}{U} \times \frac{W}{X} = \text{revs. per min. of shaft Y}$$

and of grooved pulleys 2, 3, and 4.

With the values mentioned in the text we have—

$$160 \times \frac{6}{18} \times \frac{35}{144} \times \frac{18}{64} \times \frac{18}{64} = \frac{1050}{1024} =$$

approximately 1 rev. per min.

Taking the working or effective diameter of the largest grooved pulley 4 to be 5 ft., the circumferential or surface speed will be 5 ft. $\times$ 3·1416 = 15·7 ft. per min., which represents the speed travelled by that part of the jute which is being combed as it passes from side to side of the cylinders —*i. e.*, from E^1 and F^1 to E^4 and F^4.

3. The speed of the feed sheet roller pulley 27.

$$\text{Revs. of C} \times \frac{L}{N} \times \frac{P}{Q} \times \frac{T}{\text{No. } 27} =$$

revs. per min. of feed roller 27.

Hence—

$$160 \times \frac{6}{18} \times \frac{35}{144} \times \frac{18}{5} = \frac{140}{3} = 46{\cdot}6 \text{ revs. per min.}$$

Finally, if we assume that the feed roller itself is $4\frac{1}{2}$ in. diameter, we have—

$$46{\cdot}6 \times \frac{4{\cdot}5}{12} \times 3{\cdot}1416 = 54{\cdot}899 \text{ ft. per min.}$$

Consequently, the surface speed of the feed sheet is approximately $3\frac{1}{2}$ times that of the largest grooved pulley 4, and this difference results, as already indicated, in the root ends of the jute being carried forward quickly, and literally

thrown amongst the teeth of the quickly revolving cylinders E and F. Immediately this happens, that particular strick is clearly no longer under the influence of the feed sheet, and hence the various parts of the strick move at the same rate as the parts of the grooved pulleys with which they are in contact.

The other type of so-called snipping machine is somewhat similar to a strong card without workers or strippers. It is often termed a teazer, and is used for opening out waste, ropes, and other coarse material. The feed rollers are constructed to give either a forward or a backward movement at the will of the operative. The pieces of jute are spread on the feed cloth of the machine in the usual way, and when the root end has passed sufficiently far between the feed rollers into the machine for the necessary cleaning of the roots, the movement or motion of the feed rollers is reversed, and the jute is thus drawn out of the machine.

The chief objection to both these machines is the fact that a large amount of tow or waste is made, and a large amount of time lost because of the necessity for reversing the feed rollers. And even if a skilled and careful operative is in charge of the machine, there is a considerable amount of tow combed out with the roots. In consequence of the difficulties involved in the treatment of the roots, and because of the production of waste, several attempts have been made to deal with the fibre more economically.

One method which is extensively practised, and which has the undoubted advantage of involving the use of the very simplest kind of apparatus, is that of cutting the jute. This operation consists in most cases of severing the root ends of the stricks with the aid of a long deep knife—sometimes a scythe is used. In every case, however, the knife, which is usually from 30 in. to 36 in. in length and 5 in. to 6 in. in depth, is held stationary.

One type of knife and fittings are illustrated in Figs. 66 and 67 in front and end elevations. An ordinary trestle has two holes made in its upper cross-beam A. The threaded bottom parts of the knife-holders B are passed through these holes and bolted as shown, while the knife C itself is fixed securely in the two forked ends of the holders B. The whole is usually weighted or otherwise

securely fixed, in order that no movement will take place durin the process of cutting. In some cases an even simpler arrangemen obtains: an iron rod is fixed in a plank which rests on the floor The upper end of the rod is arranged with suitable knife-holders and weights are placed on the plank to keep it firm. It can the be easily moved from place to place as desired. The operativ takes the jute in both hands and cuts off as much as he think necessary by drawing the strick over the edge of the knife. Wit

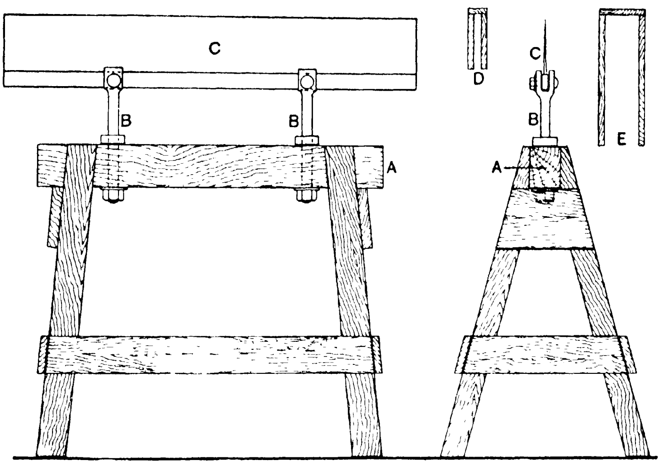


FIG 66. FIG. 67.

constant use and with sharpening, the knife edge naturally get worn until the upper surface or edge is concave in form.

Since these knives are exceedingly dangerous, they should alway be covered with a sheath when not in use. Two kinds of sheath are shown at D and E in Fig. 67. The former is intended to cove the blade only and to rest upon the upper faces of the knife-support B, whereas sheath E is intended to cover both knife and support and to rest upon the top beam of the trestle. The forked part then effectively prevent any part of the cover from touching th sharp edge of the knife. In some cases leather sheaths are used but in no case should the knife be exposed when out of use.

The foregoing processes represent the complete routine adopted in the preparing departments of mills in which pressed-packed bales are used. Somewhat modified conditions naturally obtain in practically all the large Indian jute mills—the difference in procedure is caused mostly by the method of buying and making-up of the jute. Since no shipping in the general sense is involved in the despatch of jute for the Indian mills, it is usual to pack the fibre in more or less loose bundles and in two forms:—

1. The Kutcha or country bales, which contain about $3\frac{1}{2}$ maunds (288 lb., but often up to 300 lb.).
2. The drums, which contain one to two maunds ($82\frac{2}{7}$ lb. to $164\frac{4}{7}$ lb.), the actual quantity varying in different districts.

And since both kinds of bundles are lightly pressed, it is evident that a bale-opener is unnecessary.

Huge godowns or warehouses are required for the storage of the loosely packed bundles, and, in addition to these permanent buildings, there are several temporary stores erected early in the season. The jute in this case is built up in the open and covered with suitable wrappings, and it may be possible to sort the jute before it is stacked. In most cases, however, the fibre is bought unassorted, which obviously necessitates some modified arrangement in the batching department to suit these conditions. For instance, in some of the large Indian jute mills the bundles are conveyed to selectors into the batching or sorting department, and here assortments are made suitable for:—

1. Hessian warps.
2. Hessian weft and sacking warp.
3. Sacking weft.

If a root-comber is used it will clean all the rough ends and provide the long jute necessary for sections 1 and 2, while the combings and selected rough pieces will be drafted into section 3. When the jute has been discharged at the mill, wharf, or ghat, it is necessary to examine it with regard to moisture, and also to see that the bulk is equal in value to the sample lots; this early precaution saves litigation later. The method adopted in India to ascertain the excess moisture is to open out the fibre and to leave it in this state for 24 hours under cover, and sheltered from the sun's

rays and the rain. Not more than 10 per cent. of the delivered weight should evaporate; if there is a greater percentage, the difference in value is deducted before payment.

The degree of selection for each class will vary in different mills, and will be influenced by the class of cloth it is intended to make. It may be quite safe in some of the mills to purchase lower grades of jute for mixing with the assorted lots, and in other mills to purchase an occasional good lot to mix with and to keep the batches

FIG. 68.

up to a standard quality which must, of course, prevail all the year round.

The quantity of water and oil to be used on the jute during the operations will also fluctuate more than it does in temperate countries. During the worst period of the rainy season the air becomes absolutely saturated with moisture, and very little evaporation takes place; consequently, a minimum amount of water must be added. Conversely, much more water must be added in the hot season when evaporation proceeds rapidly because of the dryness of the air. Without this additional amount of water the climatic condition would be quite unsuitable for this particular branch of textile work.

We conclude the description of the processes leading up to carding by the introduction of Fig. 68, which has been taken recently in one of the largest Dundee jute mills. The cutting knife and the method of cutting off the roots is clearly indicated. The uncut jute is shown in the barrow on the left, the cut jute in the barrow on the right, while the bag near the knife-stand is for the reception of the jute roots. The latter are placed on one side to be treated separately.

CHAPTER VI

THE EVOLUTION AND OBJECT OF CARDING

CARDING.—Before illustrating and describing the actual machines which are used for what is known as "carding" in the preparation of the jute fibre, it will perhaps be advantageous to discuss briefly the evolution of carding, the object of the process, and the difference in general between this system and the one which in certain cases is employed for the production of higher-class yarns, or for yarns which possess different physical features from those prepared by a system in which carding is the fundamental process.

It is probably impossible for any person to possess the knowledge which will enable him to state with absolute certainty the date of the origin of carding, or even to say for which fibre the carding implements were first used. It is even a matter more or less of conjecture as to whether wool or flax was first used for the formation of a textile thread. Historic records provide us with information which appears to leave no doubt as to the great antiquity of both these fibres, and since it is practically impossible to form a thread from a large number of individual fibres without some kind of operation which straightens out the fibres and lays them more or less parallel to each other, we are probably safe to assume that the process of carding, in a very crude form indeed, was originally practised in connection with either the wool fibre or the flax fibre. The actual modern mechanical operations involved for the treatment of the wool fibre, either for woollen yarns or for worsted yarns, are quite different from those which are in use for the flax fibre, and hence also for the jute fibre, since those practised for the latter have been evolved from, and are indeed modifications of, those employed for flax.

One is inclined to the opinion that the wool fibre holds precedence, since this valuable raw material is obtained as such, as it were, direct from the sheep, without having to undergo any specially

long and tedious process such as is necessary to extract flax and similar fibres from their natural envelopes. Whether this opinion is correct or not, it is quite evident that, in the early ages, as the sheep wandered about from place to place, and probably among a larger and more imperfectly cultivated collection of shrubs and vegetable growths than what is at present found in enclosures for sheep, the small tufts of wool would collect on the spiny fruit of such shrubs. From these spiny fruits it would be a simple step to a crude form of comb, and with the advance of civilisation would

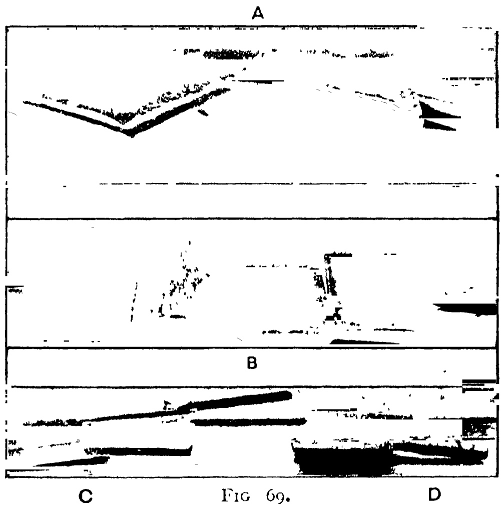


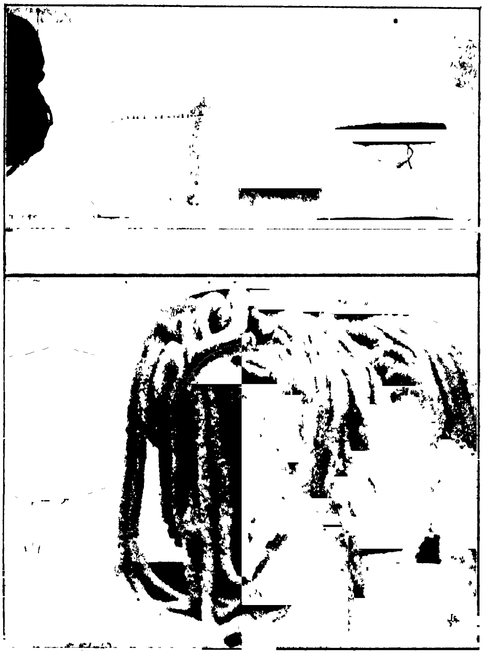
FIG 69.

follow in natural steps the evolution of the hand-cards which are still used in many country districts.

The teeth of what we may be allowed to style "modern hand-cards" are not straight, but are slightly bent near the middle as shown at A and B in Fig. 69. These two views show respectively one pair and two pairs of hand-cards with their pins or teeth uppermost. When the working parts of a pair of hand-cards are in contact as illustrated at C in the same figure—that is, with the handles pointing in opposite directions—the points of the two sets of teeth, and therefore the bends of the teeth, oppose each other.

As the two cards are drawn in opposite directions, the teeth of one set hold the bunch of fibres while those of the other set straighten out any crossed fibres which happen to lie obliquely to the direction of movement. The motion of the two hand-cards is continued in the same directions—*i. e.*, one to right and one to left—until all the

E



F

FIG. 70.

fibres are laid straight. Then by reversing the direction of one of the cards, as indicated at D, Fig. 69, the straightened group of fibres is removed from the other card in the form of a roll or curl as illustrated at E, Fig. 70. A longer length of roll doffed from similar cards is illustrated at F, Fig. 70, while the yarn on the left has been spun from similar rolls.

Strange and crude as this process will undoubtedly appear to those who are conversant with the modern mechanical methods of carding and scribbling wool for woollen yarns, or for combing wool for the production of worsted yarns, it was the forerunner of the beautiful, unique, and intricate mechanism which at present is established in modern spinning mills. It is also the forerunner of perhaps the equally complicated mechanism used in other branches of spinning, including, of course, flax and jute, and we therefore offer no apology for introducing a few remarks on fibres which actually are outside the scope of the present work.

The remarkable and valuable changes which have taken place in this branch of work, as well as in others, due to the introduction of machinery, are elegantly described in Baines' work on the *History of the Cotton Manufacture* as follows: "Mechanical knowledge has taught man to substitute for the labour of his own hands the potent and indefatigable agency of nature. The operations which he once *performed* he now only *directs*."

A further step was the introduction of much larger cards about 3 ft. wide, but the first real attempt at mechanical carding, or rather the first patent which deals with this branch, is that taken out in the name of Lewis Paul, on the 30th August, 1748, and numbered 636. The apparatus consisted of a concave board clothed with card teeth, and a cylinder, similarly clothed, the circumference of which was concentric with the concave board. It will thus be seen that the operation of carding was simplified, since it was only necessary to turn the cylinder by a handle and the production increased considerably. The concave board could be lowered in order to strip or doff the carded wool by means of a series of needles in a rod, and resembling a long steel comb. Each successive cardful of carded wool was joined to the last lot carded in order to make a continuous roll or sliver. These simple yet ingenious parts formed the nucleus of which the modern card is the result.

The end of the eighteenth century and the beginning of the nineteenth century witnessed improvements in connection with the carding of wool and of cotton, and about this period experiments were conducted in the mechanical preparation and spinning of flax tows; the evolution of the modern cards for flax and jute probably dates from this time.

About this date the function of the card for flax tow was the same as that for wool and cotton—that is, straightening the fibres to enable them to be laid parallel to each other, and thus lay the foundation for the production of a decent and comparatively level sliver, and ultimately a level thread. A machine, however, which is suitable for short fibres such as cotton, and for comparatively short and medium fibres such as wool, is scarcely adapted for the much longer flax fibres, and is certainly unsuitable for the still longer jute fibres, unless these be cut to suitable lengths. Consequently the cards for the flax trade were gradually altered and improved to enable them to cut the fibres, and also to clean off impurities at the same time.

There are some rather interesting notes recorded by a Dundee spinner, Mr. William Brown, who carried out many experiments previous to the year 1820. He considered, and probably rightly, that the process of tow spinning at most mills was defective, and he attributed the defects almost entirely to the carding engines. The cards which were in use previous to 1820 were unsuitable for the work to be performed, but one must remember that those engaged were still feeling their way, and could hardly be expected to arrive immediately at a satisfactory solution. The toothed cylinders of the cards were continually getting choked with strips or patches of tow, and this not only hindered the work, but decreased the production, and incidentally produced inferior slivers and ultimately defective yarns. The card clothing or cover was too fine for the work, being similar to that used for wool and cotton; moreover, the speed of the main cylinder, which was only 3 ft. in diameter, was too slow. This cylinder ran at 90 revs. per min., but afterwards the speed was doubled. The introduction of more coarsely pitched teeth in the clothing, and the increased speed imparted to the cylinder, enabled the above gentleman to overcome the difficulties entirely in his mill, and to produce a reasonable quantity of material from the machines. In his description of the working of his card Mr. Brown says: "The main cylinder is about 3 ft. in diameter by the same in length, having two divisions of card cloth on it, each about 14 in. wide. The feeding rollers with one clearer (now termed strippers), a single worker with clearer, a frizzler for clearing the main cylinder, a doffing sheet and rollers

which differed only slightly from those of later times." The quantity of tow produced daily in 14 hours was 1 cwt. About this date flax was selling as high as £150 per ton, and the price of 6 lb. tow yarn was 10s. 3s. per spindle (1s 8½d. per pound).

The ideas of Mr. Brown were evidently on the right lines, for the modern circumferential speed of the cylinders is much higher than that which enabled the above improvements to be obtained, and considerably higher than that which resulted when the comparatively low diameter cylinders made only 90 revs. per min.; the teeth of the card clothing in the modern cards also differ entirely from the ones used in former times.

Although the modern method of carding resembles much that which obtained about the above-mentioned period, the conditions with regard to the preparing of both flax and jute have altered considerably. In the early days of carding, the flax fibre was very clean, and large quantities of Dutch and home-grown flax were used; but when the spinning of jute was attempted, the greatest defect in the mechanism was experienced in connection with the cards. The cheaper class of flax would undoubtedly be treated on the cards at the same time that the jute fibre was undergoing its trials. Much, however, had to be learned ere success was assured, and we are safe in saying that the methods of preparing the fibre at and for the cards were deficient, and presented some of the greatest difficulties in the successful treatment of the jute fibre.

THE OBJECT OF CARDING.—In its widest sense the object of carding is that of laying the fibres parallel. In the jute industry, as well as in the flax industry, the operation also includes the breaking down of the long stalks or strips of the fibre, and it is quite possible that this operation of shortening or breaking the fibres has led to the adoption of the term "breaker card" as universally applied to the machine which is used in the initial process. Apart altogether from the general and almost self-evident requirements of the carding machines, there is at least one other object which, although apparently neglected, is nevertheless unconsciously considered by even those who scorn to consider the theoretical side in the slightest degree. We refer to the desirability of keeping in mind the physical structure of the ultimate thread.

There are at least three conditions which, when satisfactorily

fulfilled, place the spinner of the finished yarn in an advantageous position.

1. The yarn should be as near as possible of uniform thickness throughout its entire length.
2. The yarn should be practically uniform in strength.
3. The yarn should be of the maximum strength for the particular type, and for the purpose for which it has to be used.

These conditions are obvious when pointed out, but the operations which are necessary to secure these valuable and important conditions are often imperfectly performed. Statements such as the above are calculated to invite criticism, and perhaps to be flatly contradicted, because there are so many practical phases which make it very difficult indeed to achieve perfection, or anything approaching perfection, except with the very finest kind of fibre, extended mechanical processes, and careful and conscientious operatives. And we must admit at once that under certain conditions, even with the aid of the best type of workers, it is impossible to achieve uniformity. It is not impossible, however, to make a few suggestions which may help to improve the ultimate value and appearance of any particular type of yarn, however low in quality that yarn may be.

The production of what may be called an ideal yarn implies the use of ideal fibres, and also demands perfection in all mechanical and manual operations; and, since the operations and fibres do not reach this stage of perfection, it follows that an ideal yarn does not exist. Notwithstanding these impossible phases, we can define an ideal thread or yarn as one which is composed of a number of individual filaments or fibres so arranged that each cross-section of the yarn contains the same number of filaments, and that all the filaments are of the same length. It is only when the constituents of a yarn closely approach these ideal conditions, and these are approached closely in some cases, that anything like uniformity in strength can obtain.

It may be argued that since such a high degree of regularity is well-nigh impossible, it is foolish to attempt an approach to ideal conditions. We are certainly not of that opinion; on the other hand, we are confident that much better results are attainable when

all possible precautions are taken. If a series of transverse sections of a thread be cut, they will almost invariably show that the number of fibres in such sections is not uniform; and if the thread be examined longitudinally, we are safe to predict that there will be a great disparity in the lengths of the various fibres. These inequalities are not so great in line yarns as they are in tow yarns, for the twofold reason that the fibres are selected and sometimes cut to approximately the same length for the production of line yarns, whereas for tow yarns no such treatment is attempted. Some slight choice of fibres with regard to thickness may take place in certain cases for flax tow yarns for the purpose of improving the quality, but the chief factor in most cases, other than the personal element, in determining the quality of any particular type of yarn, is undoubtedly the action of the card clothing on the various rollers and cylinder, and the speeds and setting of the various rollers. If the fibres differ greatly in diameter, this difference will certainly affect the ultimate conditions. The diameters of the fibres, as well as the yarns made from them, should be and are proportional to the square root of their sectional areas.

(It is easy to show diagrammatically that the twist in yarns—*i. e.*, the number of turns per inch—should vary in inverse proportion to the square root of the sectional area of the thread, and therefore in inverse proportion to the square root of the count of jute yarns. Now the degree of twist which is imparted to a thread has a very important bearing on the strength of the thread, and consequently it follows that, other things being equal, uniformity in strength can only be secured by uniformity in twist. It will be observed that twist is not mentioned in the three conditions which are stated as being essential for the production of the highest class yarns, simply because, when the diameter is uniform, the twist is also uniform. If, however, the yarn, through any cause or causes—*e. g.*, uneven fibres, roots, slubs, joinings—is thick and thin, the number of turns per inch varies in the two parts, and this results in varying strengths. The fewer the number of turns per inch, and the shorter the fibres, the more easily will those fibres be displaced and thus weaken the yarn, for it is obvious that a straight fibre is more easily withdrawn from a group than is one which winds spirally around and with its neighbours.

It appears to us, therefore, that in order to minimise the diversity in strength in any yarn, and to counteract in some degree the tendency to introduce that diversity which obtains in virtue of unavoidable circumstances, one should attempt to obtain :—

1. Approximately even lengths and diameters of fibre in the sliver delivered from the cards.
2. A high degree of uniformity in feeding the stricks of jute into the machine.

The latter might be secured ultimately by some method of automatic feed—it is practically out of the question to attempt to secure uniformity in slivers by a considerably extended process of doublings, since this would probably increase the cost of production to such an extent as to make the price of the yarn prohibitive. It may also be impossible to secure uniform lengths of fibres or filaments by a carding process, but we are of the opinion that a step towards this desired ideal condition would be secured by an improved method of feeding, and also by paying particular attention to the size and pitch of pins, and to the method of distributing these pins over the surface of the various rollers. We shall, however, leave this important though partially neglected consideration of pins until we have described the general operations of carding, and illustrated at least some of the mechanical parts of the breaker card.

CHAPTER VII

BREAKER CARDS—"LOW" AND "LAWSON" MACHINES

FIG. 71, which illustrates part of one of Messrs. Fairbairn's breaker cards, shows the usual method of arranging the material on the feed sheet of a breaker card: it also shows the general appearance of the feed sheet when it is uniformly covered with

FIG. 71.

the long stricks of jute which have previously passed through the softening machine. The illustration accurately represents the satisfactory manner in which the spreading of the stricks on the feed sheet is performed on some machines, as the effect was photographed without the attendant having foreknowledge of the writers' intention. It should be pointed out, however, that much of the spreading on the sheets of breaker cards is very indifferently done when compared with the filled sheet in the illustration.

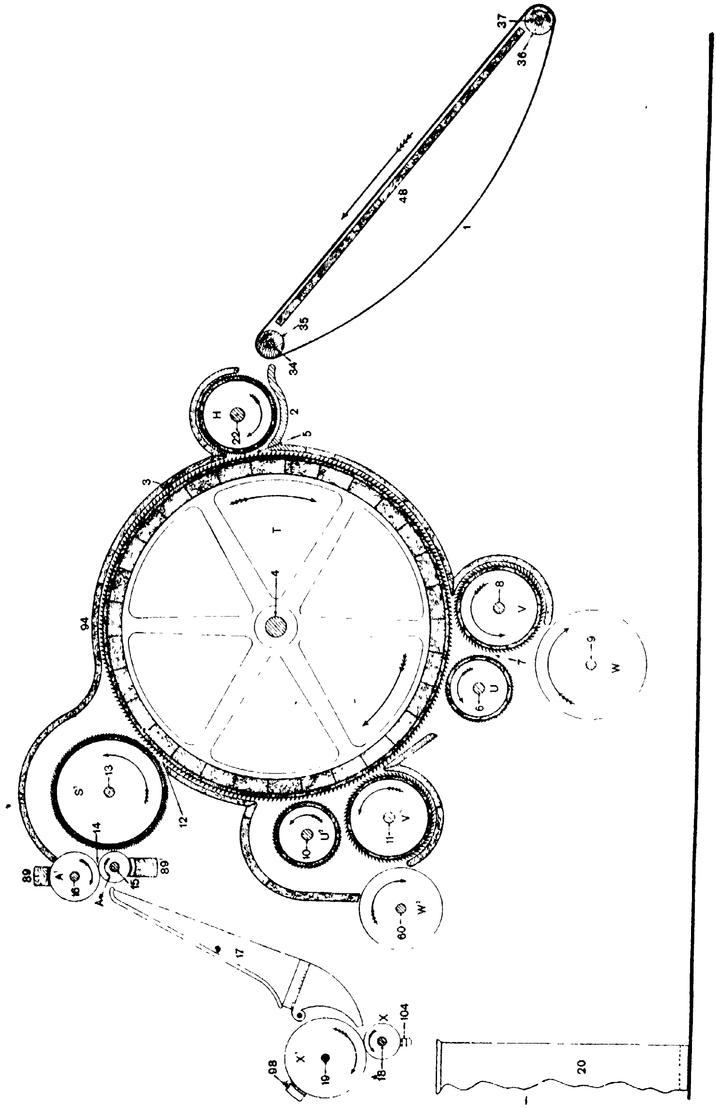

37
36
48
1
35
34
H
22
2
5
3
T
4
94
8
V
9
W
6
U
13
S'
12
14
89
15
16
A'
17
10
U'
11
V'
60
W'
X
104
X'
19
18
98
20

Fig. 72.

Fig. 72, which is a section through a breaker card, is introduced to illustrate practically all the rollers and other parts which operate on the fibre as the latter is passing through the machine. The sectional view is taken from one of the modern breaker cards made by Messrs. James F. Low & Co. Limited, Monifieth, near Dundee. The object of introducing this type of illustration first is to enable us to explain briefly the path followed by the fibre from the time it leaves the feed sheet to that of being delivered as a sliver into the sliver can at the other end of the machine.

The stricks of jute, as already mentioned, should be laid uniformly on the feed sheet 1, and when the machine is in work the stricks on this feed sheet are carried upwards, as indicated by the arrow, and fed into the machine between the teeth or pins of the feed roller H and the cast-iron plate 2, usually termed the shell. The upper surface of the shell 2 and the points of the pins of the feed roller are sufficiently near to each other to enable the fibre to be carried forward until it comes into contact with the pins 3 of the main cylinder T; the latter rotates on the main shaft 4 in the direction shown by the arrows. The stricks of jute are crushed into the pins of the feed roller H in virtue of the closeness of the setting of the shell 2, and consequently the material can move only at the same speed as that of the periphery of the feed roller H. The cylinder T, however, is moving very much quicker than the feed roller, and as the material emerges from the shell and the feed roller at the point 5, it is immediately acted upon by the pins of the cylinder T.

The combined splitting and carding actions, which will be discussed more fully later, begin at this point, and are continued at the first worker U^1, which revolves on shaft 6 in the direction shown, but at a much slower speed than the cylinder T. A portion of the material is retained by the first worker U^1, while the remainder passes forward. That portion retained by the first worker U^1 is carried round by it in the direction of the arrow, and is ultimately removed from it at the point 7 by the first stripper V^1 on the shaft 8. The stripper carries the fibre again into the pins of the cylinder T in the direction indicated. The tin cylinder W^1 on shaft 9 is placed in a suitable position to assist the first worker U^1 in carrying the fibre towards the first stripper V^1, and also to minimise the production of waste.

This cycle of operations performed by the cylinder T, the first worker U^1 and the first stripper V^1, is repeated by the cylinder and the second pair of rollers U^2 and V^2 on the shafts 10 and 11. A second tin cylinder W^2 is provided in some machines for the second pair, but omitted in others.

The carding action in breaker cards is completed at this stage, and the carded fibre is now carried forward to the point 12, where it is removed by the pins of the doffing roller S^1; this roller rotates on the shaft 13 in the direction shown. The pins of the doffing roller S^1 carry the fibre around the top of the roller to the point of contact 14 of the drawing and pressing rollers A and A^1 on shafts 15 and 16. After the fibre emerges from these rollers it is in the form of a thin fleece or sheet of carded material, and this sheet is conveyed and contracted into what is universally known as a sliver, as well as conducted by the tin conductor 17 between the delivery rollers X and X^1 on shafts 18 and 19, and ultimately into the sliver can 20.

The description of the passage of the fibre already given was introduced at this stage solely for the purpose of assisting in the description of the other working parts of a similar machine illustrated by the three complete line drawings in Figs. 73, 74, and 75 These represent the breaker card made by the Lawson Branch of Messrs. Fairbairn Lawson Combe Barbour Limited, Leeds and Belfast.

Fig. 73 is an elevation of the driving or belt side of the machine; Fig. 74 is an elevation of the opposite side, and contains most of the gearing; while Fig. 75 is a plan, drawn partly in section for the sake of showing more clearly the connections between the various rollers and the gear-wheels. The same lettering and numbering appear for similar parts on all the four drawings, and the same scheme of identification will be adopted in connection with any other views which involve detailed parts of the machine.

A few of these machines are now driven direct by individual motors, but the usual arrangement is to drive from a drum on the line shaft and a belt 21 to the fast and loose pulleys Y and Y^1 which are placed on the main cylinder shaft 4. On shaft 4, but at the opposite side of the machine (see Fig. 74), is placed the cylinder pinion J—the end of the shaft 4 being turned down to about 1½ in.

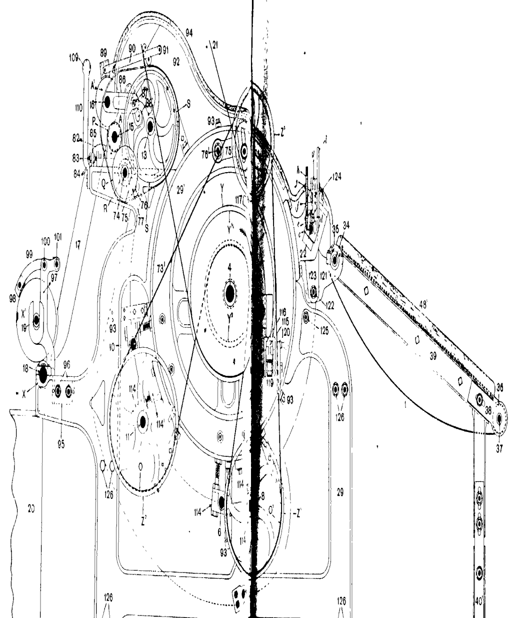


Fig. 73.

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diameter to receive it. The pinion J communicates the motion to two main trains of gear-wheels which end respectively at the feed roller wheel G on shaft 22 and at the drawing roller wheel B on shaft 15. Both these trains of gears, however, are required in their entirety for other purposes. Thus, the former is utilised for the feed-sheet gear, and the latter for the doffing and delivery gears; while, in addition, a portion of the drawing-roller gear is utilised for the train of wheels for the workers.

Taking the first train of wheels for the driving of the feed roller H, it will be seen that the pinion J first drives the intermediate wheel 23 on the stud 24. This stud is fixed on the radial arm 25, and is adjustable for various sizes of cylinder pinions J by means of the concentric slot 26, and a bolt 27. The intermediate wheel 23 in turn drives the compound wheel and pinion C and D on the stud 28 fixed to the side frame 29 of the machine. Pinion D then drives the second compound wheel and pinion E and F on the stud 30. This stud 30 is fixed to the radial arm 31, which is provided with a concentric slot 32, and bolt and nut 33, to accommodate different sizes of change pinions F. The latter pinion F drives the feed roller wheel G on the shaft 22, upon which is also fixed the feed roller H.

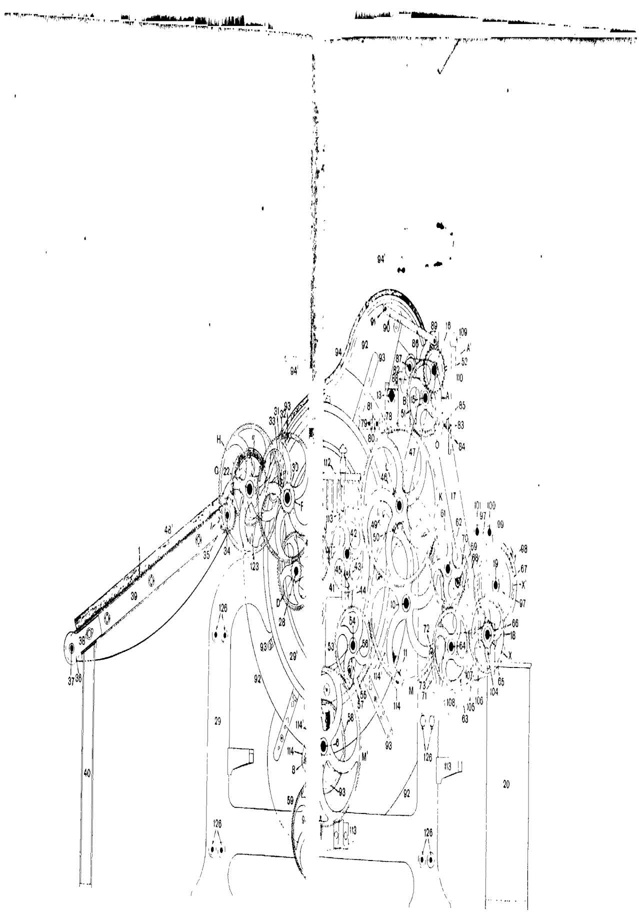
On the same shaft 22, but nearer to the framework 29, is a wheel *a* which drives the pinion *b* on the end of the shaft 34 of the upper roller 35 for the feed sheet. The feed sheet 1 passes over this roller, as well as over the lower roller 36 on shaft 37 of the feed sheet. The surface speed of the feed sheet 1 has therefore a definite relation to the speed of the other parts. The lower roller 36 of the feed sheet can be adjusted within limits by means of two brackets 38 which are bolted to the side rails 39 of the feed table. The upper ends of these two side rails swing on the shaft 34 of the upper roller of the feed sheet, while their lower ends may be supported by two single upright brackets 40, as shown in Fig. 62, or by two adjustable brackets 40^1, as shown in Fig. 73. The feed sheet passes over an inclined wooden table 48, and between the two wooden side rails 48^1. The table is supported by the iron side rails 39. The feed sheet itself is usually made from heavy jute or flax canvas, but a heavy felt or plaiding sheet is much more satisfactory, and although the first cost of the latter is greater than that of the canvas, the outlay is probably cheaper in the end.

Now let us consider the second main train of wheels. Commencing from the same cylinder pinion J, Fig. 74, on shaft 4, motion is conveyed to the intermediate wheel 41 on stud 42. The latter is attached to stud plate 43, which is provided with a slot 44, and the usual bolt fastening 45. Wheel 41 drives the compound wheel and pinion K and L on stud 46, but for the train of wheels under consideration the pinion L is not included; its use in connection with a further train of wheels will be explained shortly. Stud 46 is on the radial bracket 47, which is fulcrumed on the shaft 15 of the drawing roller A. The bracket 47 is also provided with a radial slot 49, and bolt 50. The large wheel K finally drives the drawing-roller wheel B on the shaft 15.

The continuation of this drive for the purpose mentioned above commences with the shaft 15. On this shaft, but nearer the side frame 29 than wheel B, is a pinion 51, which drives the wheel 52 on the shaft 16 of the pressing roller A^1. The ratio of the teeth in pinion 51 and wheel 52 is the same as that of the diameters of the two rollers A and A^1.

As already mentioned, wheel K is simply an intermediate wheel for the drive from the cylinder pinion J to the drawing roller A, but this wheel K and the pinion L form a compound for the train of wheels to the worker. Thus, pinion L gears with and drives the wheel M on the shaft 10 of the second worker U^2, Figs. 72 and 74. The wheel M also drives the intermediate wheel 53, which is carried by a stud 54 on the stud plate 55. The latter has a slot 56 and a bolt 57 for adjustment. The intermediate wheel 53 thus drives the second worker wheel M^1 on the shaft 6. A little nearer to the side frame 29, and on the shaft 6, is keyed a wheel 58, which drives the wheel 59 of the tin cylinder W^1 on the shaft 9. In Fig. 74 there is no tin cylinder shown at the second pair of rollers U^2 and V^2, but in Fig. 72 the tin roller W^2 on shaft 60 is geared in a manner similar to that shown for the tin cylinder W^1.

The wheel K also drives the delivery rollers X and X^1 on shafts 18 and 19 by means of the following train of wheels:—Intermediate wheel 61 on stud 62, intermediate wheel 63 on stud 64, and wheel 65 on the shaft 18 of the bottom delivery roller X. On shaft 18 is fixed a pinion 66 which drives the wheel 67 on the shaft 19 of the roller X^1; the ratio of the wheels 66 and 67 is the same as that of



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the diameters of the rollers X and X^1. The stud 62 is carried in the radial bracket 68 fulcrumed on the stud 46, and is fixed by a bolt 69 in the slot 70. Similarly, the stud 64 is carried on the radial arm 71, fulcrumed on shaft 18, and fixed by the bolt 72 in the slot 73.

The gearing to the doffer wheel S is illustrated in Figs. 73 and 75. In Figs. 73 the pitch lines of the wheels are shown by solid circles, but in Fig. 75 the face of the teeth is indicated in the usual way. On the end of the drawing-roller shaft 15, but on the belt side of the machine, is a pinion P which gears with the wheel Q, and thus drives the compound wheel and pinion Q and R on the stud 74. The latter is fixed in the adjustable bracket 75, which is provided with the usual slot 76 and the fixing bolt 77. The pinion R ultimately drives the doffing wheel S on the end of the shaft 13 of the doffing roller S^1.

The two ends of the doffing roller shaft 13 are supported in the sliding brackets 78; these brackets are adjusted on the frame 29 by means of screws 79, nuts 80, and lugs 81, which are screwed into and project above the upper faces of the side frames 29. In a similar manner the ends of the shaft 15 of the drawing roller A are provided with sliding brackets 82, screws 83, lock-nuts 84, and lugs 85.

The two ends of the shaft 16 of the pressing roller A^1 are held by two brackets 86 fulcrumed on the studs 87; the latter are fixed in their proper positions in the slots 88 in the upper parts of the sliding blocks 82. A stationary rubber 89 rests upon the roller A^1, and is supported by the two arms 90, which are fulcrumed at convenient places on the studs 91; the latter are fixed to and project from the shrouding 92. The shrouding encloses the ends of all the carding rollers, and is attached to the side frames 29 by a series of brackets 93. Part of the boxing or wooden covering is shown outside the shrouding on the top of the card. The boxing is arranged in curved form over the upper surfaces of the feed roller, the cylinder and the doffer, and consists of fixed parts and movable parts; the fixed parts are marked 94, and so are the movable parts or doors when closed; the latter are provided with hinges, and where shown wholly or partially open are marked 94^1, as in Fig. 74.

A rail 95 is held between the two side frames 29 by bolts 96,

and this rail forms the support for the brackets 97 of the delivery roller X^1. The rubber 98 on the pressing roller X^1 is carried by the two arms 99 fulcrumed on the short shaft 100. A second short shaft 101, immediately behind 100, and also supported by brackets 97, serves to support the arms when the latter are turned back clear of the roller. The delivery roller shaft 18 is protected by the covers 102, and the latter are supported by the brackets 103, which are bolted to the rail 95. The under rubber 104, termed a dead rubber, forms one end of the lever 105, fulcrumed at 106, in the bracket 107, which is bolted to the rail 95. The short arm of lever 105 is kept in contact with the lower roller X by the weighted part 108 of the long arm. The rail 95 also forms a kind of platform for the operatives, and for safety it is compulsory to provide a handrail 109; this rail extends across the machine, and is supported by two brackets 110, which are bolted to the frames 29. As a further safeguard against accidents, cages 111 are provided. These open outwards on the vertical rod 112, and when closed are supported by various brackets 113. The stripper and worker shafts 6, 8, 10, and 11 are supported by bearings 114, and the stripper bearings are provided with screwed studs, so that they may be adjusted accurately, with regard to radial distance, in the tapped ends of the base supports 114^1, the latter may also be moved, within limits, on the periphery of the ring 29^1. In this particular machine, the ring 29^1, which carries the bearings 114^1 for the strippers and workers, is bolted to and forms part of the frame 29; this arrangement gives a minimum distance between the bearings at the two sides.

On the end of the feed-roller shaft 22, and at the belt or driving side of the machine, Figs. 73 and 75, is a double thread worm *c*, which drives compound wheels *d* and *e*. An intermediate wheel *f*, on adjustable radial arm *g*, conveys the motion to the wheel *h* on the clock spindle *j*. A hand *k* is attached to the end of this spindle, and moves in the usual way in front of the clock face *l*.

Projecting from and bolted to the side frame 29 is a bracket 115, Figs. 73 and 75, the underside of which bracket is provided with a rack. A bracket 116 carries the belt fork 117, and also a short shaft or stud 118, upon which is a small pinion 119. The latter is in

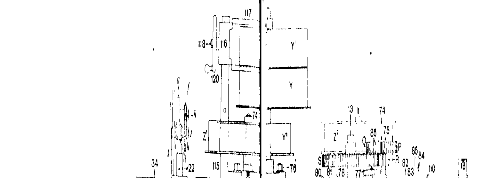

FIG.

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gear with the rack on the under surface of the bracket 115; hence the bracket 116 may be made to move in either direction on the bracket 115, and to carry the belt fork 117 similarly in either direction by means of the hand-wheel 120, which is also on the same stud 118 as the pinion 119.

We might just mention that the shell 2 in Fig. 72, or, rather, the upper surface of it, is concentric with the feed roller H. Swinging brackets, not shown in Fig. 72, but illustrated at 121 in Fig. 73, provide means for adjusting the shell 2 to the cylinder T. These brackets, when in the desired positions, are fixed by the bolt 122 to the brackets 123; the latter form part of the side frames. Another bolt 124 serves to adjust the feed roller to the shell. A bolt 125 is provided for adjusting the shrouding 92, while substantial bolts 126 are employed to secure the usual cross-rails to the side frames 29.

It will be seen from Fig. 73 that the shafts 8 and 11 of the two strippers receive their motion from a belt 73^1 which runs on the stud 74^1 near the free end of the tension pulley bracket or radial arm 75^1; the latter is fulcrumed at 76^1. The tension pulley Z^3 can be swung nearer to or farther from the shaft 4 in virtue of the concentric slot in the radial arm 75^1, and when the belt 73^1 is taut, the radial arm 75^1 is fixed securely by the bolt as indicated.

The following list has been prepared to serve as a ready table, and also to facilitate the selection of any particular wheel or part of the machine in connection with the various calculations and the adjustment of the different sections:—

A = drawing roller, 4 in. diameter.
A^1 = pressing roller, 7 in diameter
B = wheel of 72 teeth on drawing roller A
C = ,, 72 ,, of compound C and D.
D = pinion of 18 ,, ,, C ,, D.
E = wheel of 120 ,, ,, E ,, F.
F = pinion of 20 to 50 teeth of compound E and F.
G = wheel of 120 teeth on feed roller shaft 22.
H = feed roller of 8 in. diameter under cover.
J = cylinder pinion of 48 teeth on shaft 4.
K = wheel of 150 teeth of compound K and L.
L = pinion of 25 to 45 teeth of compound K and L.
M = wheel of 150 teeth on shaft 10 of 2nd worker U^2.
M^1 = ,, 150 ,, ,, 6 ,, 1st ,, U^1.
N = (marked Y^2 in Figs. 73 and 75) pulley of 14 in. diameter on cylinder shaft 4.

O = pulleys of 20 in. diameter on shafts 8 and 11 of 1st and 2nd strippers V^1 and V^2.
P = pinion of 24 teeth on shaft 15 for driving doffer wheel S.
Q = wheel of 48 teeth of compound Q and R.
R = pinion of 25 ,, ,, Q ,, R.
S = wheel of 96 teeth on shaft 13 of doffing roller S^1.
S^1 = doffing roller of 14 in. diameter under cover.
T = main cylinder of 48 in. diameter under cover.
U^1 = 1st worker of 7½ in. under cover diameter on shaft 6.
U^2 = 2nd ,, 7½ in. ,, ,, ,, 10.
V^1 = 1st stripper of 12 in. ,, ,, ,, 8.
V^2 = 2nd ,, 12 in. ,, ,, ,, 11
W^1 = 1st tin cylinder of 10 to 16 in. diameter on shaft 9.
W^2 = 2nd ,, 10 to 16 in. ,, ,, 60.
X = delivery roller of 4¼ in. ,, ,, 18.
X^1 = pressing ,, 12 in ,, ,, 19.
Y = fast pulley of 24 in. ,, ,, 4.
Y^1 = loose ,, 24 in. ,, ,, 4.
Z^1 = stripper pulley on shaft 8 for stripper belt.
Z^2 = ,, ,, shaft 11 ,,
Z^3 = tension ,, stud 74^1 ,,
a = wheel of 66 teeth on shaft 22 of feed roller H
b = ,, 33 ,, ,, 34 of sheet roller 35.
c = double thread worm for driving clock
d = pinion of 24 teeth of compound *d* and *e*.
e = wheel of 39 ,, ,, *d* ,, *e*.
f = intermediate wheel of 30 teeth
g = radial arm for adjustment of wheel *f*
h = wheel of 60 teeth on clock spindle *j*.
j = clock spindle.
k = clock face
l = hand of clock.
1 = feed sheet.
2 = shell
3 = pins in cylinder T.
4 = shaft of ,, T.
5 = point where fibre first meets pins of cylinder T.
6 = shaft of 1st worker U^1.
7 = point where fibre is removed from 1st worker U^1 by 1st stripper V^1.
8 = shaft of 1st stripper V^1
9 = ,, 1st tin cylinder W^1.
10 = ,, 2nd worker U^2
11 = ,, 2nd stripper V^2.
12 = point where fibre is removed from cylinder T by doffer S^1.
13 = shaft of doffer S^1.
14 = point of contact between drawing and pressing rollers A and A^1.
15 = shaft of drawing roller A
16 = ,, pressing ,, A^1.
17 = tin conductor.
18 = shaft of delivery roller X.
19 = ,, pressing ,, X^1.
20 = sliver can.
21 = driving belt from mill shaft to pulleys Y.
22 = shaft of feed roller H.
23 = intermediate wheel of 48 teeth conveying motion from pinion J to wheel C of compound C and D.
24 = stud for intermediate wheel 23.

25 = radial arm for intermediate wheel 23.
26 = slot of arm for intermediate wheel 23.
27 = bolt and nut for fixing radial arm 25.
28 = stud for compound C and D.
29 = side frames of machine.
29^1 = ring.
30 = stud for compound E and F.
31 = radial arm for stud 30.
32 = slot of arm ,, ,,
33 = bolt and nut ,, ,,
34 = shaft of upper roller 35 for feed sheet 1.
35 = upper roller for feed sheet 1.
36 = lower ,, ,,
37 = shaft of lower roller 36 for feed sheet 1
38 = adjustable brackets for lower roller 36 of feed sheet 1
39 = side rails of feed table 48
40 = upright supports for side rails 39.
40^1 = ,, ,, ,, 39
41 = intermediate wheel of 72 teeth conveying motion from wheel J to wheel K of compound K and L.
42 = stud for wheel 41
43 = stud plate for wheel 41.
44 = slot in stud plate 43
45 = bolt and nut for stud plate 43.
46 = stud for compound K and L.
47 = radial bracket for compound K and L
48 = feed table
48^1 = wooden rails on sides of feed table 48.
49 = radial slot in radial bracket 47.
50 = bolt and nut for fixing radial bracket 47.
51 = pinion of 16 teeth on shaft 15 of drawing roller A.
52 = wheel of 28 ,, ,, 16 of pressing roller A^1
53 = intermediate wheel of 72 teeth between wheels M and M^1.
54 = stud for intermediate wheel 53
55 = stud plate for ,, ,, 53.
56 = slot in stud plate 55.
57 = bolt and nut for fixing stud plate 55.
58 = wheel of 112 teeth on shaft 6 of 1st worker U^1 for driving wheel of 1st tin cylinder W^1
59 = wheel of 128 teeth on shaft 9 of 1st tin cylinder.
60 = shaft of 2nd tin cylinder W^2
61 = intermediate wheel of 72 teeth to delivery roller X.
62 = stud for intermediate wheel 61.
63 = intermediate wheel of 72 teeth to delivery roller X.
64 = stud for intermediate wheel of 72 teeth to delivery roller X
65 = wheel of 72 teeth on shaft 18 of delivery roller X.
66 = pinion of 17 ,, ,, 18 ,, ,,
67 = wheel of 48 ,, ,, 19 of pressing roller X^1.
68 = radial bracket for stud 62.
69 = bolt and nut ,, ,,
70 = slot in radial bracket 68
71 = radial arm for intermediate wheel 63.
72 = bolt and nut for radial arm 71.
73 = slot in radial arm 71.
73^1 = belt for driving stripper pulleys Z^1 and Z^2.
74 = stud for compound Q and R.
74^1 = stud for tension pulley Z^3.

75 = adjustable bracket for compound Q and R.
75^1 = radial arm for tension pulley Z^3.
76 = slot in radial arm 75
76^1 = fulcrum for radial arm 75^1.
77 = bolt and nut for bracket 75.
78 = sliding brackets or blocks for shaft 13 of doffing roller S^1.
79 = screws for moving sliding blocks 78.
80 = nuts for adjusting ,, ,,
81 = lugs in frame 29 for screws 79.
82 = sliding blocks for supporting shaft 15 of drawing roller A.
83 = screws for moving sliding blocks 82.
84 = nuts for adjusting ,, ,,
85 = lugs in frame for screws 83.
86 = brackets on studs 87 for pressing roller A^1.
87 = studs for brackets 86.
88 = slots in brackets 86.
89 = stationary rubber for pressing roller A^1.
89^1 = felt on bottom of stationary rubber 89.
90 = arms for carrying rubber 89.
91 = studs in shrouding for supporting arms 90.
92 = shrouding.
93 = brackets for shrouding.
94 = boxing.
94^1 = boxing opened out.
95 = front rail for supporting delivery and pressing rollers X and X^1.
96 = bolts for fixing front rails to side frames 29.
97 = brackets for pressing roller X^1.
98 = rubber resting on pressing roller X^1.
99 = arms for carrying rubber 98.
100 = short shaft for supporting arms 99.
101 = short shaft for supporting arms 99 when they are swung back.
102 = protecting covers.
103 = brackets for covers 102.
104 = under-rubber against delivery roller X.
105 = lever for rubber 104.
106 = stud for lever 105.
107 = brackets for lever 105 and stud 106.
108 = weighted end of lever 105.
109 = safety handrail.
110 = brackets for supporting handrail 109.
111 = protection cages.
112 = centre bar for protection cages.
113 = brackets for cages 111.
114 = bearings for strippers and workers.
114^1 = adjustment for strippers and workers.
115 = bracket on frame for supporting set-on handle.
116 = sliding bracket on 115.
117 = belt fork.
118 = shaft for rack pinion 119.
119 = rack pinion of 16 teeth.
120 = handwheel for moving belt fork.
121 = bracket for supporting shell 2.
122 = nut for adjusting shell 2 to cylinder T.
123 = bracket for fixing nut 122 and shell 2.
124 = bolts or studs and nuts for adjusting and fixing feed roller H.
125 = studs and nuts for adjusting shrouding.
126 = bolts and nuts for rails and frames.

127 = radial line for finding tangent circle.
128 = tangent on stave to radial line 127.
129 = angle of pins 3, and line to fix radius for the tangent circle.
130 = tangent circle for pins of cylinder T
131 = ,, ,, workers U^1 and U^2.
132 = ,, ,, strippers V^1 and V^2.
133 = tapped eyebolt for holding adjustment stud 114^1 of worker firmly to ring 29^1.
133^1 = untapped socket for holding adjustment bolt 114^1 of worker firmly to ring 29^1.
134 = nut for fixing adjustment bolt 114^1 to ring 29^1.
135 = tapped socket of stripper bearer 114.
136 = semi-circular bearers for stripper adjustment stud 114^1.
137 = projections on bearers 136 to fit into corresponding slots in ring 29^1.
138 = projecting part from frame 29 for bolt 139.
139 = bolt and nuts for adjusting socket 114.
140 = slot in bearer 114.
141 = bolts and nuts for fixing bearing 114 to ring 29^1.
142 = oil for cylinder shaft 4.
143 = drip cup.
144 = bolt for holding doffer bearer 78 firmly.
145 = set-screws for fixing block 82.

References to other machines will be made, so that the above-mentioned letters and figures will, as far as the chief parts are concerned, apply in all cases.

Fig. 72 shows clearly that several of the rollers are provided with teeth or pins, the function of which will be explained shortly. The corresponding rollers in Figs. 73 to 75 are also covered with a similar set of pins. The pins are fixed into their respective staves, and each pin in any given type of stave, and for any particular type of roller or cylinder, is set at a definite angle to the tangent of the circle at its point of emergence from the upper surface of the stave. The pins in the various kinds of rollers are naturally made of those dimensions which are considered most suitable for the work which they have to perform.

Fig. 76 shows about 14 in. of five different staves taken from the machine illustrated in Figs. 73 to 75. Each stave is approximately $23\frac{5}{8}$ in. long, and in the machine three of them are placed end to end so as to extend from side to side of the cylinder and rollers; this distance is usually 6 ft. They are fixed to the under cover by stout screws, and one pin or more is missed at this point, as illustrated in Fig. 76. When these staves are arranged round and fixed to the rollers as exemplified in Fig. 72, the roller is said

to be covered or clothed, and the complete arrangement of the staves is consequently termed the "covering"; it is also often termed the "card clothing.")

The pins for the same purpose vary slightly in different machines,

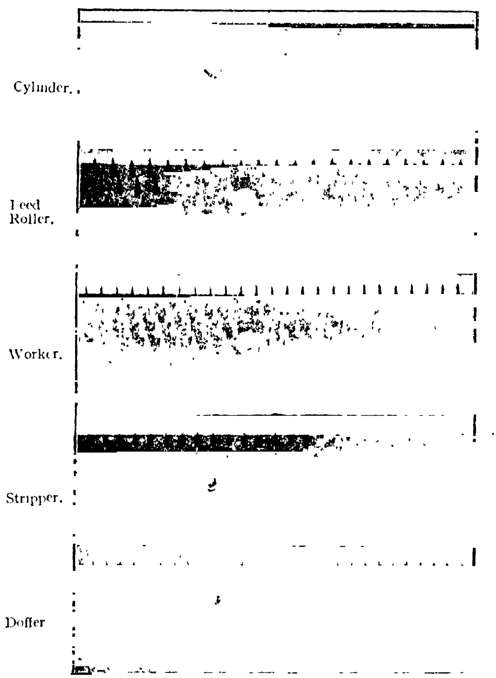

FIG. 76.

but the general characteristics are very similar, as will be gathered from Fig. 77, which shows two complete sets, numbered 1 to 6 and 7 to 12, for breaker cards; the two sets in Fig. 78, numbered 13 to 26, are typical of staves which are used for finisher cards, and these latter staves will be referred to when this type of card is discussed. It will be seen that the pins in staves 7, 8, 9, 10, and 12

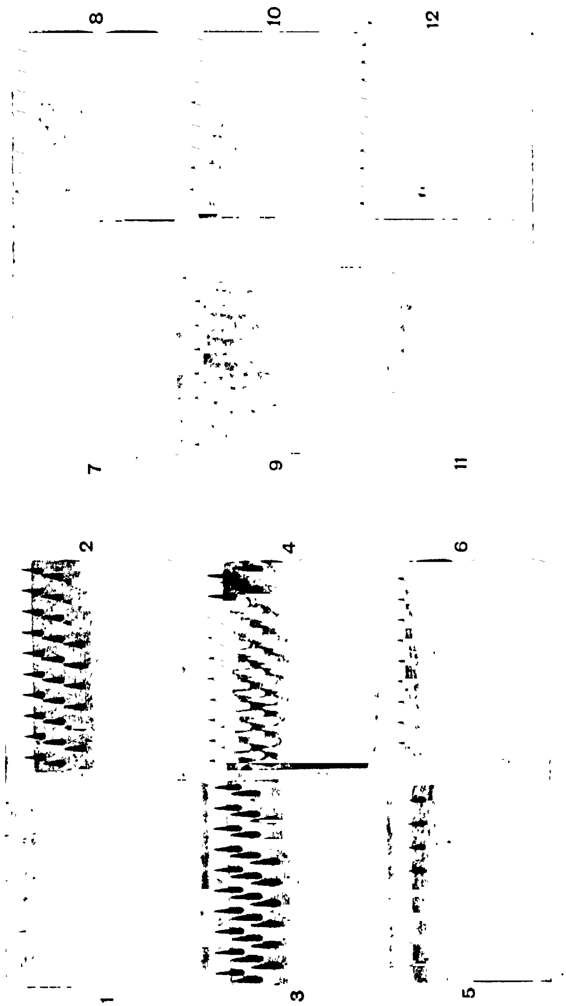

FIG. 77.

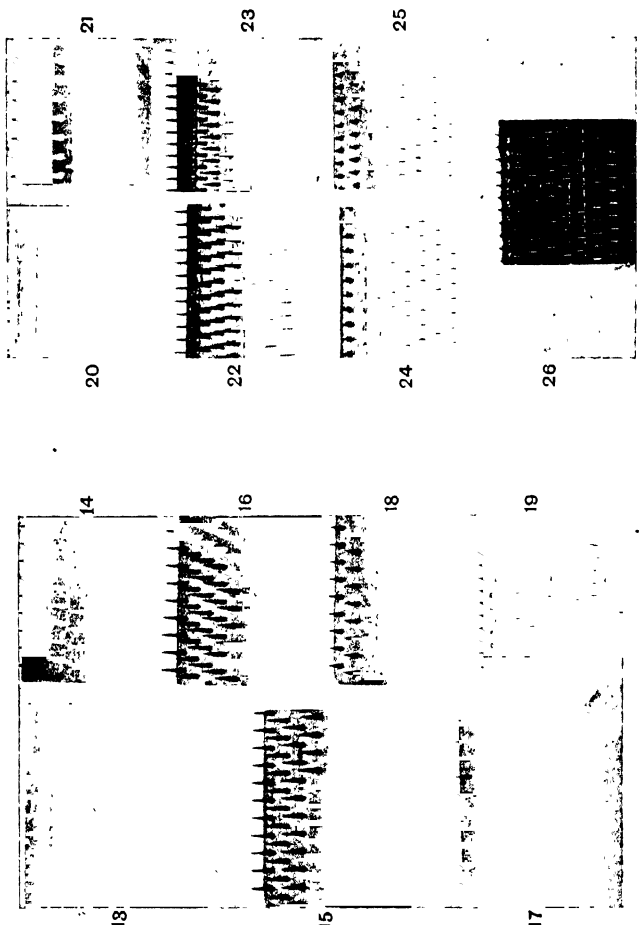

FIG. 78.

are strengthened by iron plates, and these plates are fixed to the wooden staves by screws.

Staves 1, 7, 13, and 20 are for cylinders
,, 2, 8, and 21 are for feeders
,, 3, 4, 9, 10, 15, 16, 22, and 23 are for workers.
,, 5, 11, 17, 18, 24, and 25 are for strippers
,, 6, 12, 19, and 26 are for doffers.
Stave 14 is for a feed stripper.

The pins are distributed in different ways over the surfaces of the staves, and the method of distribution is designated the pitch of the pins. This pitch is usually given in terms of the distance between two successive pins in two directions—vertically and horizontally.

There may be, and are, staves with different pitches of pins used on similar or identical machines by the same maker, according to the class of material to be worked, or according to the ideas of different managers. One scheme of covering for the card illustrated in Figs. 73 to 75 is described below:—

Name of Roller.	Pitch of Pins.	Wire Gauge Number.	Total Length of Pin.	Approximate Angle Between Pin and Tangent to Circle.
	In. In.		In	Deg.
Cylinder . . .	$\frac{1}{16} \times \frac{1}{16}$	12	1	71
Feeder . . .	$\frac{1}{2} \times \frac{1}{2}$	12	$1\frac{1}{4}$	52
Workers . . .	$\frac{7}{16} \times \frac{3}{8}$	12	$1\frac{5}{8}$	41
Strippers . . .	$\frac{7}{16} \times \frac{7}{16}$	12	$1\frac{1}{8}$	43
Doffer . . .	$\frac{3}{8} \times \frac{3}{8}$	14	$1\frac{1}{4}$	40

Following this scheme of covering we supply a table with several other particulars, amongst which will be found the surface speeds of what we have taken to be the approximate working diameter of the various rollers. The method of calculating these surface speeds will follow in the first group of calculations. In the following table we take the various rollers as they appear in Fig. 72, commencing with the cylinder, and then working round clock-wise from the right-hand side.

Name of Roller	Diameter of Under-cover	Diameter Over Stave.	Diameter Over Middle of Pins	Circumference Over Middle of Pins.	Revolutions per Minute.	Surface Speed in Feet per Min. Over Middle of Pins or Over Periphery.
	In.	In.	In.	In.		
Cylinder T	48	49⅛	49½	155·31	190·00	2459·10
Feed roller H	8	9⅛	9¾	30·63	4·43	11·31
1st Stripper V¹	12	13⅛	13½	42·41	133·00	470·00
1st Worker U¹	7½	8⅞	9½	29·85	12·97	32·26
2nd Stripper V²	12	13⅛	13½	42·41	133·00	470·00
2nd Worker U²	7½	8⅞	9½	29·85	12·97	32·26
Doffer S¹	14	15⅛	15½	48·69	16·49	66·91
Drawing roller	4	—	—	—	126·66	132·64
Delivery roller	4¼	—	—	—	126·66	140·93
Feed sheet roller	4	4½ over sheets	—	—	8·86	10·44

The last two columns show conclusively that there is a great difference between the speeds of the various rollers, and an even greater difference between the surface speeds. The relative surface speeds of the various rollers are very important, but before discussing their effect on the carding operation we propose to introduce the chief calculations which are necessary for obtaining the proper relation between the raw material and the sliver.

CHAPTER VIII

CALCULATIONS FOR "LAWSON" BREAKER CARD. DISCUSSION ON CARDING

For the benefit of those who are not very familiar with the functions which the various wheels play in a train of gear, we have prepared the model train of wheels illustrated in Fig. 79.

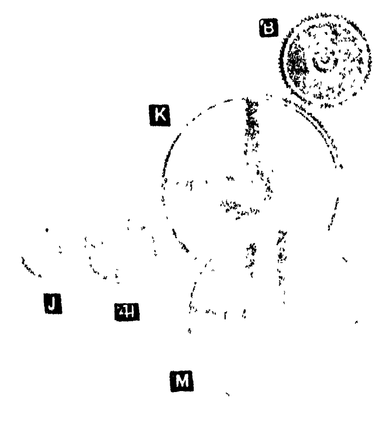

Fig. 79.

The part played by these six wheels is identical with that played by the six wheels in Fig. 74 and marked J, 41, K, B, L, and M. With the exception of wheel J, however, the number of teeth in the corresponding wheels in Fig. 79 is slightly different. We shall consider the wheels in Fig. 79 solely for demonstration purposes, although the use of the similarly placed wheels of identical signification in Fig. 74 will be quite clear.

The first train of wheels in Fig. 79 involves J, No. 41, K, and B, and of these No. 41 and K act solely as intermediate wheels—that is, they convey or transmit the motion from driving wheel J to driven wheel B, and also cause the latter to rotate in the proper direction, but without altering the circumferential speed of the wheels.

When one or any odd number of intermediate wheels are used, the driving and driven wheels rotate in the same direction, but when two or any even number of intermediate wheels are used, the driving and driven wheels rotate in opposite directions. Hence wheels J and B in Fig. 79 rotate in opposite directions. If, therefore, wheel J makes 99 revs. per min. counter-clockwise, wheel B will make—

$$99 \times \frac{48}{70} = 67\tfrac{31}{35} \text{ revs. per min. clockwise.}$$

It will be clear that the drive from wheel J to wheel B is quite independent of the pinion L of 48 teeth, although both K and L are on the same stud, and work in unison as far as angular motion is concerned. Pinion L may be slipped off the stud if desired, and the motion would still be transferred from J to B as usual. It is equally clear that both wheel K and pinion L are required to drive the wheel M. In this case wheel K and pinion L are termed a compound, and they change the speed of subsequent wheels. One complete revolution of wheel K, and, naturally, one complete revolution of pinion L, will operate only 48 teeth of wheel M, simply because it is pinion L which drives wheel M. And in a similar manner, one revolution of wheel J will operate only 48 teeth of wheel K. In other words, it takes three revolutions of J to make one revolution of K, and three revolutions of K, and also of L, to make one revolution of M. Hence the speed of wheel M with respect to the speed of wheel J, which we have assumed to be 99 revs. per min., will be—

$$99 \times \frac{48}{144} \times \frac{48}{144} = 11 \text{ revs. per min.}$$

This reduction in speed, or the converse, is the sole purpose of all compound wheels, but in the case under consideration it is

evident that wheel K is simply an intermediate wheel for one train of wheels, J to B; while with pinion L it forms a compound for another train of wheels, J to M. For the purpose of ascertaining the direction of motion only, the compound may be considered as one wheel, and then an even number between the driving wheel J and the driven wheel M changes the direction of motion as in the

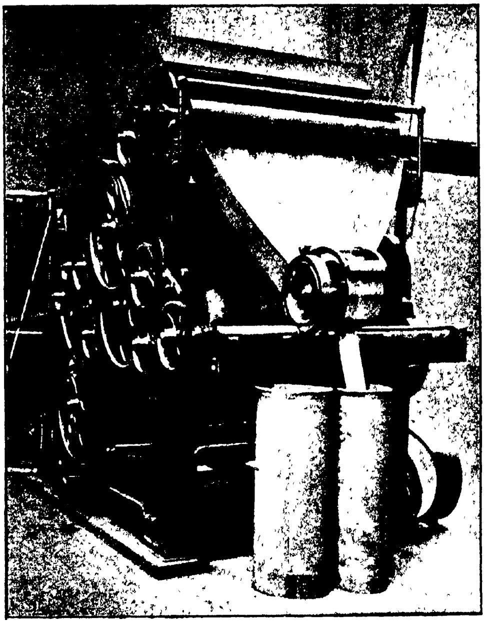

FIG. 80.

case of ordinary intermediate wheels, while an odd number between J and M would result in both J and M rotating in the same direction.

There are several trains of gear illustrated in Figs. 73 to 75, and the above description of the principles involved will probably be of assistance immediately in connection with the large number of wheels used.

From the time that the jute fibre is fed on to the feed sheet

in Figs. 71 and 72 to the time that it emerges from the drawing rollers in Fig. 80, and ultimately from the delivery rollers into the sliver can, the material has undergone a remarkable change in character and in appearance; it has, indeed, been converted from a more or less uneven group of thick stricks, first into a very fine film or fleece of material shown emerging from between the drawing rollers in the upper part of Fig. 80, and then into a much narrower but thicker group of fibres, termed a sliver, also illustrated in the same figure between the delivery rollers and the sliver can.

The width of the very fine film near the drawing rollers is quite as wide as the width occupied by the stricks on the feed sheet in Fig. 71, and hence there has been a decided attenuation of the material between the feed roller H and the drawing roller A, Fig. 74. This reduction in the thickness of the material is, of course, necessary, and the elongation thus effected between the feed roller and the drawing roller is invariably distinguished by the technical word "draft." The draft varies according to the requirements of the sliver for specific purposes.

The formula for all calculations regarding this branch is represented in a general form as under, where the letters refer to the wheels in Fig. 74. For the sake of reference we purpose numbering each equation.

$$(1) \qquad \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{H} = \text{the draft.}$$

And since F is the change pinion (see list of parts, p. 131), it follows that—

$$(2) \qquad \frac{A \times C \times E \times G}{B \times D \times H} = \text{draft} \times F.$$

If for our particular numerical example we introduce the values of the wheels and rollers represented by the above letters in Fig. 74, we have—

$$(3) \qquad \frac{4 \text{ in.}}{72} \times \frac{72}{18} \times \frac{120}{28} \times \frac{120}{9 \cdot 75} = \text{the draft}$$
$$= 11 \cdot 72.$$

From this numerical example it is evident that with these particular values of wheels and rollers one may obtain what is termed

a "constant" or a constant number. This number can then be used for the purpose of obtaining quickly the number of teeth in a change pinion F for a given draft, or to find the draft which would result from the use of any size of change pinion F. In other words, the product of the change pinion and the draft is equivalent to the constant number as indicated in the algebraical example marked (2). From the actual numbers involved we have—

$$(4) \qquad \frac{4 \times 72 \times 120 \times 120}{72 \times 18 \times 9{\cdot}75} = 328{\cdot}2, \text{ say } 328$$

= the constant number for this machine.

Hence—

$$(5) \qquad \frac{\text{Constant number}}{\text{Change pinion F}} = \text{draft};$$

and

$$(6) \qquad \frac{\text{Constant number}}{\text{Draft}} = \text{change pinion F}.$$

The draft may also be obtained as follows:—During the time that the machine is in motion an average length of stricks, practically as wide as the feed sheet, passes into the machine every minute, and an average length of a very thin film or fleece emerges per minute from the drawing rollers. Now, it is quite evident that if the total weight of stricks which passes into the machine per minute is not equivalent to the total weight of the thin fleece which leaves the drawing rollers per minute, minus the small amount of waste and foreign matter which drops out in the process, the material would either collect somewhere in the card or else the card would ultimately get empty. Neither of these conditions happens, for it is well known that a continuous sheet of fleece and of sliver is delivered when the card is in good working order. Therefore, from the great difference in the thickness of the material at the feed and drawing rollers respectively, it is evident that the surface speed of the thin fleece must be greater than that of the stricks, and hence the draft may be obtained by dividing the speed of one by the speed of the other as under:—

$$(7) \qquad \frac{\text{Surface speed of drawing roller A}}{\text{Surface speed of feed roller H}} = \text{draft};$$

that is—

$$(8) \qquad \frac{\text{Revs. of A} \times \text{dia. of A} \times 3 \cdot 1416}{\text{Revs. of H} \times \text{dia. of H} \times 3 \cdot 1416} = \text{draft.}$$

It will be shown immediately that the revolutions per minute of A and H are 126·66 and 4·43 respectively, and since π or 3·1416 cancels out, we have—

$$(9) \qquad \frac{126 \cdot 66 \times 4}{4 \cdot 43 \times 9 \cdot 75} = 11 \cdot 72, \text{ as in } (3)$$

The revolutions per minute of rollers A and H by calculation are obtained as under.—

$$(10) \quad \text{Revs. of cylinder T} \times \frac{J}{B} = \text{revs. of drawing roller A;}$$

and—

$$(11) \quad \text{Revs. of T} \times \frac{J}{C} \times \frac{D}{E} \times \frac{F}{G} = \text{revs. of feed roller H.}$$

The usual speeds for the main cylinder T are from 175 to 200 revs. per min. If, therefore, we take a good average speed of 190 revs. per min., we have—

$$(12) \quad 190 \times \frac{48}{72} = \frac{380}{3} = 126 \cdot \dot{6} \text{ revs. per min. of drawing roller A,}$$

and—

$$(13) \quad 190 \times \frac{48}{72} \times \frac{18}{120} \times \frac{28}{120} = 4 \cdot 43 \text{ revs. per min. of feed roller H.}$$

Hence—

$$(14) \qquad \frac{126 \cdot 66 \times 4 \times 3 \cdot 1416}{4 \cdot 43 \times 9 \cdot 75 \times 3 \cdot 1416} = 11 \cdot 72, \text{ as in } (9)$$

(Compare above with table of speeds on p. 140).

There are thus two different ways of finding the draft apart from the method of using the constant number as shown in (5). The latter method is, however, much the quicker way, and this, or the full calculation represented by the equation (1), or the equivalent numerical calculation as in (3), but with the proper change pinion included instead of the pinion of 28 teeth, should be used in preference to that formula which involves the surface speeds.

We might now with advantage show the calculations with

reference to the wheels and pulleys used for driving the workers U^1 and U^2, and the strippers V^1 and V^2, as well as those for the doffing roller S^1 and the delivery roller X.

Taking first the drive to the 2nd worker U^2, we have—

(15) Revs. of T $\times \frac{J}{K} \times \frac{L}{M}$ = revs. per min. of second worker U^2;

that is—

(16) $190 \times \frac{48}{150} \times \frac{32}{150} = 12{\cdot}97$ revs. per min.

Again—

(17) $190 \times \frac{48}{150} \times \frac{L}{150}$ = revs. of 2nd worker.

Hence we have—

(18) $\frac{190 \times 48}{150 \times 150}$ L = revs. of 2nd worker,

(19) $\therefore$ 0·405 L = revs. of 2nd worker, where 0·405 is a constant.

Thus, if it is desired to find the number of teeth in a change pinion L to produce a certain number of revolutions per minute of the second worker, we have—

(20) $\frac{\text{Revs. of 2nd worker}}{0{\cdot}405}$ = change pinion L required.

The strippers V^1 and V^2 are driven direct from the pulley N (marked Y^2 in Figs. 73 and 75) on the main cylinder shaft 4. The stripper belt passes from pulley N to pulleys O on the shafts 8 and 11 of the strippers V^1 and V^2. The belt is tensioned to impart the necessary amount of grip by means of the tension pulley Z^3.

(21) Revs. of cylinder T $\times \frac{\text{dia. of N}}{\text{dia. of O}}$ = revs. per min. of strippers;

that is—

(22) $190 \times \frac{14}{20} = 133$ revs. per min. of each stripper V^1 and V^2.

The equation for the doffing roller S^1 is obtained from the revolutions per minute of the drawing roller A, see (12), and one set of compound wheels on the belt side of the machine (see Fig. 73).

Thus—

(23) Revs. of A $\times \frac{P}{Q} \times \frac{R}{S}$ = revs. per min. of doffing roller S^1.

Hence—

(24) $126\cdot\dot{6}\dot{6} \times \frac{24}{48} \times \frac{25}{96} = 16\cdot49$ revs. per min. of S^1.

The wheel No. 65 of 72 teeth on the shaft 18 of the delivery roller X is driven, as will be seen in Fig. 74, from the wheel K of the compound K and L; preferably it may be considered as being driven from wheel B of 72 teeth on the shaft 15 of drawing roller A, by the following three intermediate wheels: K of 150 teeth; No. 61 of 72 teeth; and No. 63 of 72 teeth. The three intermediate wheels will thus cause the delivery roller X to rotate in the same direction as the drawing roller A, but they do not alter the speed. Moreover, since the wheels B and No. 65 contain the same number of teeth, it follows that the drawing and delivery rollers will make precisely the same number of revolutions per minute, that is—

(25) $126\cdot\dot{6}\dot{6} \times \frac{72}{72} = 126\cdot\dot{6}\dot{6}$ revs. per min. of delivery roller X.

The speed of the sliver at the delivery roller X is, however, greater than the speed of the thin fleece at the drawing roller A, because the delivery roller has a greater diameter than that of the drawing roller. The increased speed of the sliver over that of the thin fleece is termed the "lead" or the "uptake." Hence the ratio of the "lead" is proportional to the diameters of the rollers.

(26) $\frac{\text{Diameter of delivery roller X}}{\text{Diameter of drawing roller A}}$ = the lead.

(27) $\therefore \quad \frac{4\frac{1}{4}}{4}$ or $\frac{17}{16}$ = the lead

—*i. e.*, the delivery roller travels $\frac{1}{16}$ quicker than the drawing roller.

To maintain a cylinder speed of 190 revs. per min. as chosen in (12), with fast and loose pulleys Y and Y^1 of 24 in. diameter, and with the mill shaft revolving at 180 revs. per min., we should have—

(28) 24 in. $\times \frac{190}{180} = 25\frac{1}{3}$ in. drum,

neglecting the thickness and slipping of the belt.

Within recent years there has been a marked tendency to increase the speed of the mill shaft and to use larger pulleys than those mentioned.

Let us now examine more closely and in detail the operations which are conducted during this very important process of reducing the thick and uneven stricks of raw jute into the initial ribbon form or sliver. And we might state at once that there are two distinct methods employed with regard to the working of the card to produce a given weight of material in the form of a sliver :—

1. The "clock" or "dollop" system, in which a definite weight of stricks of jute is fed on to the feed sheet 1, Figs. 71 to 75, while the hand *k* of the clock makes one complete revolution.
2. The "lap" or "ball" system, in which the stricks of jute are laid on the feed sheet 1 in the usual manner, but without having been previously weighed. The resulting slivers are, however, then made up into a ball or lap, and these balls or laps are made a certain length, usually 100 yds., on a special machine termed a balling or lap machine.

Both methods are employed for the same purpose *i.e.*, to prepare the material for the finisher card. The second method of preparation will, however, be left over until a complete description of the card and its working under the first system has been discussed, and the necessary calculations referring to the weight of the sliver have been made.

A reference to the table of speeds of the various rollers will show that the surface speed of the feed roller H is very slow, and hence the stricks of jute move slowly up, and at the same speed as, the feed sheet 1. The feed sheet roller 35 is driven from the wheel G on the end of the feed roller H; hence—

(29) $$\text{Revs. of H} \times \frac{a}{b} = \text{revs. per min. of feed sheet roller 35;}$$

that is—

(30) $$4{\cdot}43 \times \frac{66}{33} = 8{\cdot}86 \text{ revs. per min. of roller 35.}$$

The feed sheet roller 35 is 4 in. diameter, and the feed sheet itself is approximately $\frac{1}{4}$ in. thick; therefore the outer diameter of the sheet is $4 + \frac{1}{4} + \frac{1}{4} = 4\frac{1}{2}$ in., while the surface speed of the outside layers of the sheet is—

$$(31) \qquad \frac{8{\cdot}86 \text{ revs.} \times 4{\cdot}5 \text{ in.} \times 3{\cdot}1416}{12 \text{ in. per foot}} = 10{\cdot}44 \text{ ft. per min.}$$

This is slightly under the surface speed of the feed roller H, and the difference between the two, neglecting the slight increase of surface speed due to the thickness of the stricks at the point where the stricks dip into the shell, is termed the "lead" of the feed roller. This slight lead prevents the stricks from collecting near the shell, and it will be evident that the ratio of the lead, neglecting the thickness of the fibre, is—

$$(32) \qquad \frac{11{\cdot}31}{10{\cdot}44} = \text{approximately } \frac{44}{41} = \text{the lead.}$$

The hand l of the clock k is also driven from the shaft 22 of the feed roller H. Thus—

$$(33) \qquad \text{Revs. of H} \times \frac{c}{d} \times \frac{e}{g} = \text{speed of hand } l.$$

$$(34) \qquad \therefore \quad 4{\cdot}43 \times \frac{2}{24} \times \frac{39}{60} = 0{\cdot}24 \text{ rev. per min. of clock hand.}$$

Consequently, for one revolution of the clock hand l we have—

$$(35) \qquad \frac{4{\cdot}43}{0{\cdot}24} = 18{\cdot}46 \text{ revs. of feed roller H.}$$

The clock, however, has no relation to time, but is introduced merely to indicate that in one complete revolution of the hand a certain length of stricks has passed up the feed sheet 1. Hence, since time is unimportant in this case, it is usual to find how many revolutions the feed roller makes for one revolution of the hand of the clock. Thus—

$$(36) \qquad 1 \text{ rev. of clock} \times \frac{g}{e} \times \frac{d}{c} = \text{revs. of feed roller H;}$$

that is—

$$(37) \qquad 1 \times \frac{60}{39} \times \frac{24}{2} = 18{\cdot}46 \text{ revs. as in (35).}$$

What is technically known as the "clock length" is therefore the length of stricks which passes up the feed sheet while the feed roller makes 18·46 revolutions. Hence we have—

$$(38) \qquad \frac{18{\cdot}46 \text{ revs.} \times 9{\cdot}75 \times 3{\cdot}1416}{36 \text{ in. per yard.}} = 15{\cdot}71 \text{ yds.}$$

The clock length varies in different makers' machines, but it is usually confined between the limits of 12 yds. and 16 yds.

The stricks move, then, as we have said, slowly with the feed sheet 1, and between the shell 2 and the pins of the feed roller H until they reach the point 5, Fig. 72. The ends of the slowly moving stricks are here brought into contact with the rapidly moving pins 3 of the main cylinder T, the surface speed of which is more than 200 times that of the pins of the feed roller H.

Now, one might imagine that at least one of three things may happen to that part of the strick which is in contact with the pins of the main cylinder T.

1. It may be broken off into short lengths by virtue of its coming suddenly into contact with pins which are revolving so much more quickly than those of the feed roller.
2. It may be able to hold together, or partially so, in spite of the severe action of the pins 3, in which case a certain amount of carding or combing would result.
3. The short fibres which adhere to each other, and thus form the strick, may be split off the sides of the strick in groups by the action of the pins 3.

It is difficult, and perhaps impossible, with the information at our command, to state precisely the exact action which takes place; but it is probably a joint action of conditions Nos. 2 and 3, and this is perhaps confirmed by a photo which we have taken of the stricks in the card at this stage. This photograph is reproduced in Fig. 81, and, in order to obtain it, the cover between the feed roller H, Fig. 72, and the 1st stripper V^1, was removed, the sides 39 of the feed table and the lower roller 36 raised, and the exposure made with the camera under the raised table. The stricks are plainly seen in this view, and portions of the combed and broken fibres are seen as becoming disengaged from the stricks, while all the stricks emphasise the fact that they have undergone a certain

degree of combing. In addition to this, the illustration shows clearly that each and every long piece of jute is broken down completely at the point where the boxing 94 of the cylinder joins that of the 1st stripper, Fig. 72. As a matter of fact, this is exactly what should happen in practice, because if the long reeds or stricks of jute could remain intact until they reach the pins of the 1st stripper V^1, they would be pulled right into the card by the joint action of the pins of the cylinder and stripper, as both sets are

FIG. 81.

moving in the same direction as the fibre is moving. This happens occasionally in a working card when the parts involved get out of adjustment.

Since the stricks are still intact with the exception of the small sections which have been dislodged, the supposition that the stricks might be broken, as mentioned in condition No. 1, may be considered as being impracticable and impossible.

If the reader refers to Figs. 8, 9, and 11, he will probably be convinced that the short fibres may, under certain conditions, be separated from their neighbours. As a matter of fact, the two fibres in Fig. 11 are already partially separated at both ends. And,

moreover, this particular kind of separation keeps intact the points of the fibres, and hence the splitting is done without injury to the material. Any other method of shortening the fibres would leave what are known as square or blunt ends instead of the fine-pointed ones. It will naturally be understood that we are not trying to create an impression that the fibres are split off in the card in such exceedingly short lengths as those illustrated in Fig 11, but that we wish to convey the idea that the lengths which are separated consist of a large number of such short ultimate fibres in cohesion, but with the extreme ends in each group pointed as suggested.

The photographical reproduction in Fig. 81 of comparatively long lengths of combed or carded stricks, and the obvious possibility of splitting up the fibres as exemplified in Fig. 11, lead us to conclude that conditions Nos. 2 and 3 are fulfilled.

Although the pins 3 of the cylinder T move in fixed vertical planes according to the disposition or pitch of the pins, the stricks of jute themselves are capable of moving a little to both sides of their normal vertical planes on account of being disturbed by the pins of the cylinder. It is therefore possible for each vertical set of pins in the cylinder to come into contact with different parts of the same strick, and thus be able to remove part of the short fibres or to split them off into lengths as indicated. And it must be remembered that this action can take place as long as the strick or part of it remains intact, and its forward movement is retarded by the grip of the shell 2 and the pins of the feed roller H. In all cases the stricks must be split up or broken down before their lower ends reach the 1st stripper V^1, Fig. 72, and, as explained in connection with, and shown, in Fig. 81. The degree of carding between the feed roller H, the shell 2, and the cylinder T, up to the point shown near the 1st stripper in Fig. 81, is largely influenced by the setting of the shell 2, and the position of the latter is in turn influenced by the quality of the fibre under treatment.

If the whole of each strick could be split up satisfactorily as indicated, each piece of fibre would retain the natural pointed ends, and the various pieces of fibre would then join with each other in the subsequent operations in the most perfect manner, for the pointed ends would be more easily and more neatly embedded

in, or laid on, the neighbouring pieces, than would be possible if their ends were square or blunt. It cannot be expected, however, that such a perfect separation can be effected at one place or point—at any rate with the machinery at present installed.

As the partially split and combed strick moves slowly down between the pins 3 of the cylinder T and the boxing 94, the length of every uncut or unsplit part of the strick which is exposed to the action of the pins is gradually being increased. So long as the fibre can resist, without breaking, the splitting and combing action of the pins of the cylinder, there will be a certain amount of fibres separated by the action of carding; but it is clear that as the length exposed increases, there is an increasing tendency for each remaining piece of fibre to break down under the stress, for a long fibre is always much more easily broken than is a short one. When this limit or breaking point of any fibre is reached, the fibre obviously breaks, and is carried away with, and at the same speed as, the pins 3 of the cylinder T.

If this theory, based upon practical experience, is correct, it would appear that the distance between the feed roller H and the lower part of the boxing 94 near the 1st stripper V^1, in Fig. 72, should be regulated to some extent by the strength of the fibres; in other words, the distance could be greater for strong fibres than for weak ones. On the other hand, it is impossible, except with great and probably impracticable alterations, to arrange the rollers for an adjustable length between the two points.

A great diversity of opinion prevails with regard to this length, and hence it is an open question as to whether the correct distance obtains in any machine. Much more research work in this direction is necessary before any definite scheme could be suggested with regard to its advantages over the various existing lengths. Fortunately, as has already been mentioned, the degree of carding between these points can be altered by the adjustment of the shell 2 with respect to its distance from the pins of the cylinder T.

It would probably be necessary to reconstruct the whole system of jute-preparing machinery if the ideal operation could be performed at one point. We have, however, suggested that a certain quantity of the fibres is broken, and it is due to this fact that two or more pairs of workers and strippers are introduced into every card.

If all these short groups of fibres could be split off in uniform and suitable lengths between the feed roller H and the bottom part of the boxing, there would be little or no cutting for the workers and strippers; the groups of fibres would be of such a suitable length and diameter that the present arrangement of rollers and pins would be incapable of holding them for further treatment.

All the separated or broken lengths, both long and short, are carried forward by the pins of the cylinder T past the pins of the 1st stripper V^1, but it is essential that the larger and longer pieces should be arrested to effect a further splitting action. These fibres are arrested by the pins of the 1st worker U^1, and held by them, or, rather, the movement of the fibres is retarded by the pins, in order that they may be further combed and split by the rapidly moving pins of the cylinder T.

The degree or extent of carding is influenced largely by the speeds of the cylinder and worker, and by the distance between them, and the carding is made possible by the particular manner in which the pins of the two rollers are placed with respect to each other. The adjustment between the points of the pins of any pair of rollers is termed the "setting" or the "gauging."

We must examine the pins in the various rollers in order to have a clear understanding of the actions which take place between them. In the first place it should be noted that the pins of the worker U oppose, or point in the opposite direction to, those of the cylinder T at the point where the two sets of pins meet. When the pins point in the direction of rotation of their respective rollers, or in that direction in which the fibre is moving, as in the cylinder T, they are said to be "pointing forwards"; whereas when the pins point in the opposite direction to that of the motion, as in the worker, they are said to be "pointing backwards." Thus, taking the rollers as they appear in Fig. 72, in which the direction of motion is shown by the various arrows, we see that—

The pins of feed roller H point backwards.
,, ,, cylinder T point forwards.
,, ,, 1st stripper V^1 point forwards.
,, ,, 1st worker U^1 point backwards.
,, ,, 2nd stripper V^2 point forwards.
,, ,, 2nd worker U^2 point backwards.
,, ,, doffer S^1 point backwards.

Both types are absolutely essential for the work, but whenever it is necessary to retain the fibres, as it were—or, rather, to retard their speed—the pins in the roller are pointing backwards, or opposite to the direction of motion of the fibre. Thus, the backward-pointing pins in the feed roller H, in conjunction with the close proximity of the shell 2, limit the speed of the stricks to that of the surface speed of the pins of the feed roller H, no matter how quickly the pins of the cylinder T are moving. It is obvious that, in addition to the function played above, the direction of the pins will also facilitate the removal of the fibre by the pins of the proper roller.

Now let us return to those comparatively long or large groups of fibres which have been combed off, or broken from, the stricks, and have been carried partially round by the pins of the cylinder T. It is absolutely essential that these long or large groups should be further split or broken. The pins of the 1st stripper V^1, being forward set, will allow these groups to pass forwards; but the pins of the 1st worker U^1, being backward set, catch the longer and larger groups and retard their speed as already stated.

The worker revolves very slowly, see table on p. 140, and its surface speed is also exceedingly slow relative to the surface speed of the cylinder, hence the above particular groups are not only prevented from moving rapidly, which gives time for combing and splitting, but in each unit of time a fresh portion of each length is brought in contact with the pins. Part of the carded fibre will remain on the worker, and will be carried slowly and gradually round by it to the point 7, Fig. 72, where it comes into contact with the forward set pins of the 1st stripper V^1. The comparatively high surface speed of the stripper enables its pins to remove the fibres from the pins of the worker in the form of a very thin layer. A quantity of dirt and dust drops out at this stage, and the partially combed and cleaned sheet of fibres is carried round into the pins of the cylinder, thus completing the work of the first pair of rollers. The fibre is then carried forward by the cylinder to the second pair of rollers—worker U^2 and stripper V^2.

It is the relative surface speeds of the cylinder and worker which determine the degree of splitting or carding which takes

place while the fibre is in contact with both. Consequently, the slower the surface speed of the worker, the longer will each group remain in contact with the two rollers; hence, to increase the carding action at this point it is necessary to reduce the speed of the worker, and, conversely, to decrease the carding action it is essential to increase the speed of the worker.

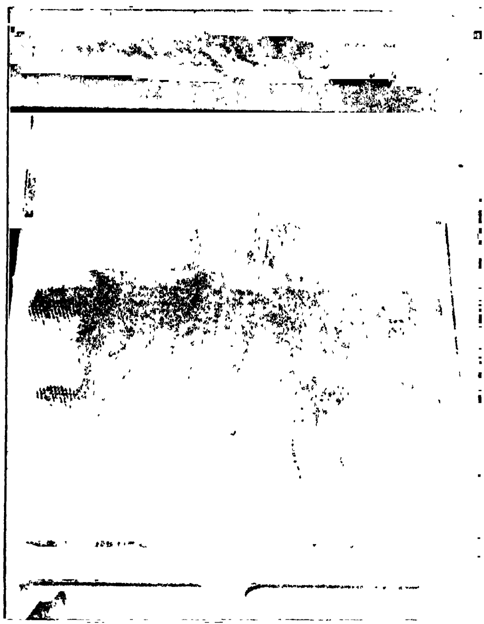

FIG. 82.

There still remains a certain quantity of fibres which require further treatment when they reach the 2nd worker. This and the 2nd stripper perform identical operations to those of the 1st worker and 1st stripper, so that by the time the fibres escape the grip of the second pair of rollers, they are comparatively short, and the material may be said to have been split up or broken down into tow, or short fibres. A comparatively thin and level sheet or

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It is the relative surface speeds of the cylinder and worker which determine the degree of splitting or carding which takes

When the sheet of carded material reaches the doffing roller S^1, part of this sheet is removed from the cylinder by the pins of the doffer S^1. This action is illustrated in Fig. 83, which was photographed with the camera above the machine. It will be seen that a small amount of fibre escapes the action of the doffer, and this fibre will be carried round again to be recarded if necessary. This point will be discussed later

The sheet of carded fibre is carried round by the doffer S^1, and removed from it at the point 14, Fig 72, by the drawing and pressing rollers A and A^1. It then passes down the conductor 17, seen best in Fig. 80, to the delivery and pressing rollers X and X^1. The convergence of the sides of the conductor, and the action of the delivery and pressing rollers, cause the thin sheet to assume much smaller dimensions, and to emerge from the latter rollers in the well-known sliver form to drop ultimately into the sliver can 20. The completed and continuous sliver is then ready for the finisher card. The rubbers 89, 89^1, 98, and 104 serve [illegible]t any fibres which become detached in any way from the sliver or thin film—that is, they keep the rollers clean and prevent the fibres from lapping on the rollers.

CHAPTER IX

GAUGING OR SETTING. ANGLE OF PINS

It will be obvious that the various rollers in the card will perform their respective functions satisfactorily only when they are placed or fixed in the most suitable positions relative to each other. To accomplish this important and delicate operation it is necessary, first, to make provision in the machine for adjusting the various rollers; and second, to be in possession of a set of gauges which aids in setting the rollers.

The gauges should be made of flat brass, and their thickness numbered according to the standard wire-gauge sizes. A complete set would include one of each of the following sizes: $\frac{3}{8}$ in., $\frac{5}{16}$ in., $\frac{1}{4}$ in., $\frac{3}{16}$ in., and wire-gauge numbers 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, and 20. In the full range of the jute trade there is no setting which cannot be made if the person in charge possesses such a set as the above.

The various points where the rollers are set may be followed in Figs. 72 to 75; the methods of moving the rollers themselves are illustrated in Figs. 84 to 86. The relative positions of the rollers obtain in Fig. 72, and the following table shows where the adjustments are, and the particular gauge to be used in the determination of the proper distance apart.

Feed roller H to shell 2	No. 20 gauge.
,, ,, cylinder T	,, 10 ,,
Shell 2 to cylinder T	$\frac{5}{16}$ in.
1st stripper V^1 to cylinder T	No. 14 gauge.
,, ,, 1st worker U^1	,, 14 ,,
1st worker U^1 to cylinder T	,, 9 ,,
2nd stripper V^2 to cylinder T	,, 14 ,,
,, ,, 2nd worker U^2	,, 14 ,,
2nd worker U^2 to cylinder T	,, 10 ,,
Doffer S^1 to cylinder T	No. 14 or 15 ,,
Drawing roller A to doffer S^1	No. 10 ,,
Pressing roller A^1 to doffer S^1	1$\frac{3}{4}$ in.

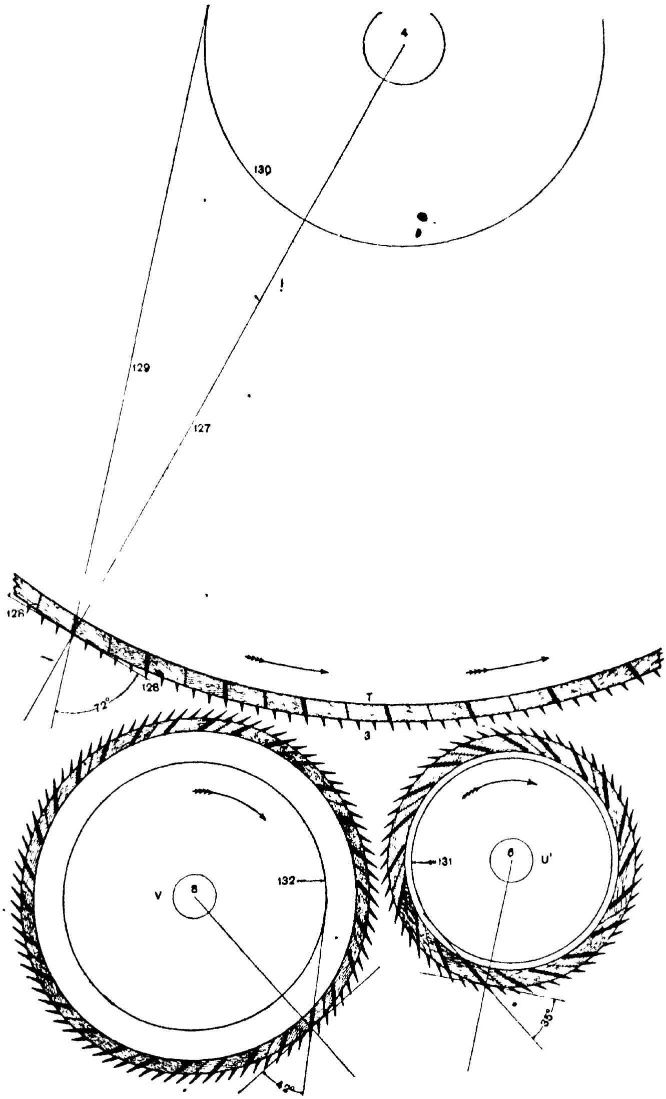

FIG. 84

Before explaining the methods of adjusting the rollers, we illustrate on a large scale in Fig. 84 one worker U^1, one stripper V^1, and part of a cylinder T, together with the method of finding the tangent circle from which the angle of the pins is obtained. The above rollers and cylinder may, for convenience, be considered as belonging to the breaker card in Figs. 73 to 75, and viewed from

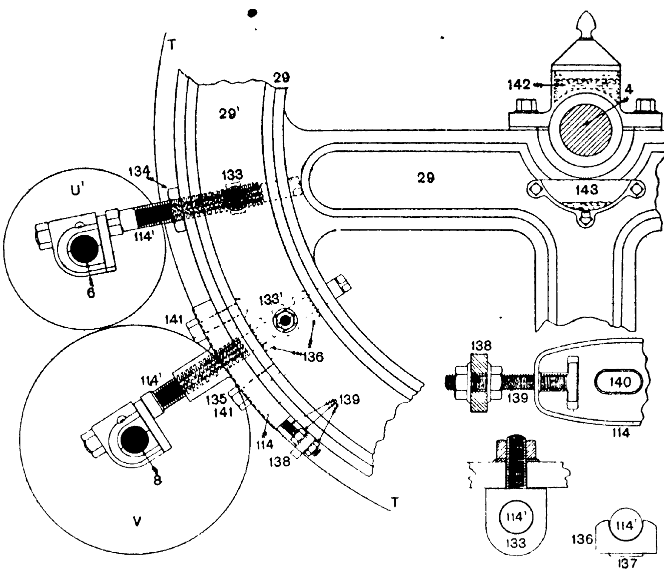

FIG. 85.

the gearing side in Fig. 74. The angles of the pins in this machine, however, are slightly different from those which we show in Fig. 84. Slight differences do obtain in practice.

The radial line 127 is introduced first, and then the tangent 128 to this radial line is drawn. In this particular illustration we have chosen 72° for the angle of the cylinder pin, and this number of degrees has been marked off as shown, and the line 129 continued to fix the radius of the tangent circle 130. The continuation of all the pins must form tangents to the circle 130. In precisely the

same way the tangent circles 131 and 132, for the angles of the pins of the worker U^1 and the stripper V^1, are found respectively by setting off the angles 35° and 42°.

The method of adjusting the worker U^1 and the stripper V^1 (and, of course, also the second pair of rollers U^2 and V^2) to the cylinder T is illustrated in Fig. 85; the points of the pins 3 are indicated in this figure by part of a circle, while those of the worker

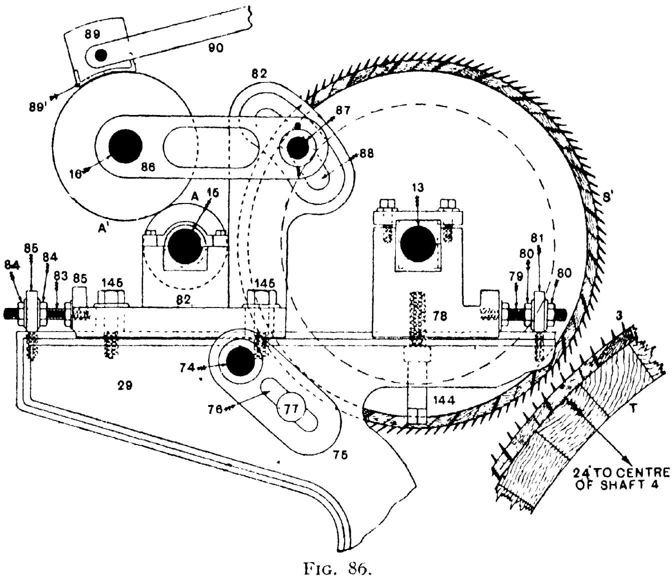

FIG. 86.

and stripper are indicated by complete circles. The adjustment stud 114^1 of the worker U^1 passes through a hole in the ring 29^1, and then through a tapped eyebolt or socket 133, and similar to that illustrated on a larger scale in one of the detached views. This socket is bolted to the ring 29^1, as shown. By slackening the nut 134 it is evident that the adjustment stud 114^1 can be moved in or out by means of a key and the squared end of the stud. When the pins of the worker U^1 are placed in their proper position with respect to those of the cylinder T—that is, when the No. 9 gauge

may be introduced between the points and to touch both sets—the nut 134 is tightened and the roller U^1 is fixed.

The adjustment stud 114^1 of the stripper V^1 passes through the tapped socket 135 of bearing 114; it also passes through an untapped socket 133^1, and when the adjustment stud 114^1 is fixed in position, it rests on two semi-circular bearings 136 (see also one of the detached figures), one on each side of the socket 133^1. A projection 137 on the base of the bearing 136 enters a corresponding slot in the ring 29^1, and thus the bearing is kept in position. These parts enable the stripper V^1 to be adjusted to the cylinder T, but the adjustment of the stripper V^1 to the worker U^1 is made by means of the sliding bracket 114, the part 138 which projects from the frame 29, and the bolt and nuts 139. An enlarged view of this section, looking from the centre of the cylinder, is shown in the upper detached view. The bolt 139 has a **T**-head which is held as shown in a corresponding slot in the bracket 114. It is evident that the bracket 114 can be moved nearer to or farther from the worker U^1, and thus place the two rollers so that the distance between the points of their respective pins will just allow No. 14 gauge to pass between them. These adjustments are naturally duplicated at the other side of the machine, and similar parts are provided for the second pair of rollers. Two slots 140, one only shown, in the bearing 114 is provided to allow for this movement; when the bearing is in its proper position it is securely fixed by bolts and nuts 141. The cylinder shaft is lubricated by small wicks; one end of each wick is on the shaft 4, and the other end in the oil 142, and a drip-cup 143 of the usual type is provided to prevent any waste of oil.

Fig. 86 illustrates the method of adjusting the doffer S^1 to the cylinder T, and also the method of adjusting the drawing and pressing rollers A and A^1 to the doffer S^1. The blocks, nuts, and screws are numbered as in Figs. 73 to 75, and it is clear that the doffer S^1 can be moved into its proper position with regard to the cylinder T by adjusting the nuts 80. When the adjustment is made so that the distance between the points of the teeth will just admit No. 14 gauge or No. 15 gauge, the block 78 is held in the proper position by the bolt 144. In a similar manner the block 82, which carries the shaft 15 of the drawing roller A, can be adjusted

by the nuts 84, until gauge No. 10 can be inserted between the pins of the doffer and the periphery of the drawing roller, when the block 82 is finally held in its proper position by two set-screws 145. Slots of sufficient length in the base of the block 82 permit of the latter being moved in either direction.

The pressing roller A^1 is adjusted by moving the stud 87 in the slot 88 in the upper part of block 82. This adjustment is usually made so that the distance between the points of the pins of the doffer S^1 and the periphery of the pressing roller is about $1\frac{3}{4}$ in. The reason for this distance will be evident if the reader again examines Fig. 83. In this figure the fibres are shown to be projecting a considerable distance from the points of the pins of the doffing roller. If the pressing roller A^1 were placed near to the pins of the doffing roller, it would fold over these projecting fibres and cause them to lie across each other, and thus prevent them from assuming the essential parallel form as they enter between the drawing roller A and the pressing roller A^1.

CHAPTER X

THE "FAIRBAIRN" BREAKER CARD WITH CALCULATIONS

Two distinct arrangements of the Fairbairn breaker card as made by Messrs. Fairbairn, Leeds, are illustrated in Figs. 87 to 90; Figs. 87 and 88 are respectively photographical reproductions of a modern and widely adopted card, from which the guards or cages were removed in order to obtain clear views of the various wheels,

FIG. 87.

pulleys, and other essential parts. The former view represents the driving or pulley side of a left-hand machine, while the latter view shows the gear side of a right-hand machine.

Figs. 89 and 90 are line drawings of the pulley and gear sides of a right-hand machine fitted with the very latest type of doffing roller and the necessary gearing to drive it. These views are also

without the cages, with the object of emphasising the mechanism proper.

Perhaps one of the first things which will command the attention of the reader with regard to Figs. 87 to 90 is the high position of the feed roller H. It is obviously much higher than the similar roller in the card which is illustrated in Figs. 72 to 75, although it is the same height as that illustrated in Fig. 71. We have already said that opinions differ amongst experts as to the best positions for the various rollers, and one need hardly say that all those who

FIG. 88

have had considerable experience with the working of breaker cards are quite entitled to their opinion. Some claim that the most natural position for the fibre to enter the machine is that represented in Figs. 87 to 90, for under such conditions the fibre, in virtue of gravity, comes quickly into contact with the pins of the cylinder. On the other hand, it is claimed by equally experienced managers and foremen that the particular position occupied by the feed roller in the other case is quite suitable. In every case the fibre is caught by the pins of the cylinder before the natural law of gravitation can effect the downward movement of the strick.

The adoption of a high position for the feed roller may necessitate,

in some cases, the use of a platform or large stool as illustrated at 146, Figs. 87 to 90; but Fig. 71, which represents the feed side of a machine in a very modern and successful preparing department of a jute mill, shows clearly that the feeding may be done without a platform, other than a very low one which is utilised for the worker's comfort. When no platform, or a very low one, is used, the feed sheet 1 must naturally be much steeper than it is when the lower adjustable rails 40′ of the feed table are supported by such a platform as that shown in the present figures. The presence or absence of a platform does not affect the method of feeding, and efficient work can be done under both conditions.

The length of the feed table is usually 6 ft.; in Fig. 90 the rails, etc., are broken for the sake of keeping the full length of the illustration within reasonable limits, but the connecting line 147 and arrows show where the two parts of the feed sheet would join if the table were drawn continuous as it appears in practice. In Fig. 89 the feed sheet is drawn straight—that is, without the usual sag in the under-part; and the two parts of the feed sheet, if joined, would form the proper length.

It has been considered advisable to introduce into Fig. 90 the smallest cylinder change pinion which is usually supplied with this machine. This pinion J contains only 20 teeth, while the largest of such change pinions for this machine has 60 teeth. The drive from the cylinder pinion J to the feed roller H involves the use of the following gear: Pinion J, wheel K, compound C and D, compound E and F, and wheel G. The drive from the cylinder T to the drawing roller A is by means of the cylinder pinion J, two intermediate wheels K^1 and K^2 of 116 teeth each, and wheel B. In connection with the breaker card illustrated in Figs. 73, 74 and 75, the drive to the drawing roller and to the workers is through the wheel K; in the present case the drive to the workers, but not to the drawing roller, is through the wheel K; hence, to keep the lettering as similar as possible for both machines, we have utilised K^1 and K^2 for the corresponding wheels which convey the motion to the drawing roller A. Whenever precisely similar wheels or parts obtain in the two machines, the lettering and numbering will correspond with the table of parts on p. 131.

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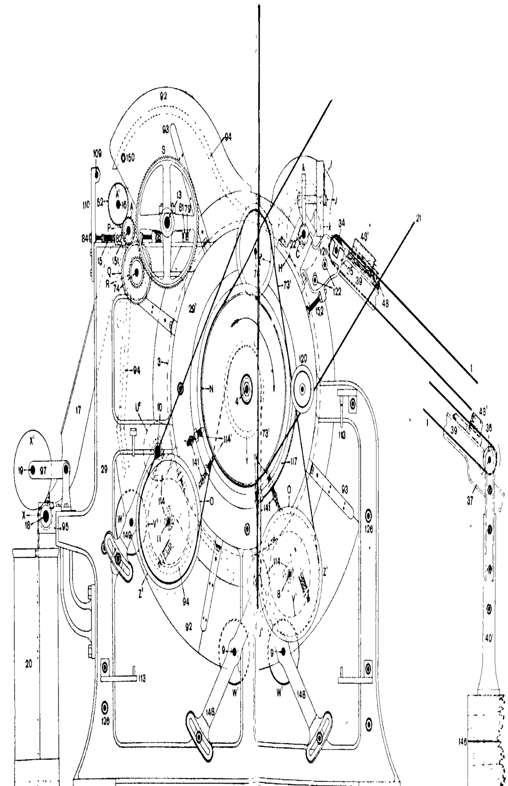


Fig. 89.

[To face page 168.

range been introduced into Fig. 90, but the smallest change pinion F has also been used. Thus the pinion F, Fig. 90, contains only 20 teeth, while the largest pinion in the usual range has 60 teeth. There is thus a wide range of change pinions to suit the desires or the necessities of all. It is very unusual, however, to have the smallest pinions J and F in one gear as illustrated, although it might be adopted in exceptional circumstances. Our purpose in introducing them is to show the use and adaptability of the radial arms for the various changes.

In Fig. 88 the cylinder change pinion J has 45 teeth, and the change pinion F has 22 teeth. In several other parts the numbers of the teeth in the wheels in Fig. 88 differ from the numbers of the teeth in the corresponding wheels in Fig. 90. The method of gearing in the two illustrations is similar in the main, with the exception of the gear to the delivery roller. Thus, the drive to the delivery roller X in Fig. 90 is clearly on the gear side of the machine, whereas the corresponding drive to the delivery roller of the machine illustrated in Figs. 87 and 88 is on the pulley side in the former view. On the end of the drawing roller A in this figure is a small pinion of 24 teeth which drives the large wheel of 54 teeth of a compound, while the pinion of 28 teeth of the compound drives the large wheel of 88 teeth on the end of the 14 in. doffing roller. The large wheel of the compound also drives the small pinion of 23 teeth on the end of the delivery roller X by means of the two intermediate wheels of 108 teeth. On the delivery roller shaft, inside the case or guard between the pinion of 23 teeth and the delivery roller proper, is a further pinion of 24 teeth, and this pinion drives a wheel of 69 teeth on the shaft of the pressing roller, so that the positive drive of the pressing and delivery rollers may deliver the sliver correctly as is exemplified by the full sliver can in Fig. 87. The number of teeth in these two latter wheels are proportional to the diameters of the rollers X and X^1. The sliver is pressed down from time to time, and when the can is properly filled, the sliver is broken and the can removed, and the adjoining empty sliver can is placed in position to receive the continuation of the sliver.

It will be observed that in the machine which is illustrated in Figs. 89 and 90 the delivery roller X, in the latter view, is driven

from the cylinder pinion J by the intermediate wheels K^1 and K^2, 61 and 63, and the wheel 65 of 51 teeth on the end of the shaft 18 of the delivery roller X.

The first worker wheel M^1, Fig. 90, on the shaft 6 of the first worker U^1, is driven from the cylinder pinion J through the compound wheels K and L and the intermediate wheel 41^1; while the second worker wheel M^2 on the shaft 10 of the second worker U^2 receives its motion from the wheel M^1 and the intermediate wheel 53. Immediately behind the wheels M^1 and M^2, and on the shafts 6 and 10, are two wheels 58 and 58^1, each containing 75 teeth. Wheel 58 drives the two wheels 59 of 84 teeth on the ends of the two shafts 9 of the two tin cylinders W^1 for the first pair of rollers, U^1 and V^1, while the second wheel 58^1 drives the wheel 59^1 of 84 teeth on the end of shaft 60 of the tin cylinder W^2 for the second pair of rollers, U^2 and V^2. The radial arms for the tin cylinders pass from the shafts 6 and 10 to suitable projections on the framework 29. Thus, radial arms 148 are for the tin cylinders W^1, and radial arm 149 for the tin cylinder W^2. The functions played by these workers, strippers, and tin cylinders are the same in all machines; and since these functions have already been explained, it is unnecessary to discuss them further.

The various stud plates and radial arms for the correct adjustment of the different rollers are plainly visible in Figs. 88 and 90.

The boxing 94 is shown mostly in Fig. 89, although the upper boxing is shown most clearly in Fig. 90. The extreme end is supported by a stud 150 and a corresponding one at the other side. The usual type of shrouding 92 is secured to the ring 29^1 by suitable brackets 93. In both Fig. 87 and Fig. 88 the general appearance of the fibre at the two ends of the machine is quite clearly illustrated. Thus, the stricks of jute are hanging over the lower end of the feed table, and the broad thin film, and ultimately the sliver, are shown respectively emerging from the drawing and delivery rollers.

The spiral spring 151, between the lock-nuts 84 and the drawing roller block 82, is introduced so that if any obstruction takes place between the doffing roller and the drawing roller, the latter may slide outwards in virtue of the possibility of compressing the spring 151. When the obstruction is removed, the spring forces the

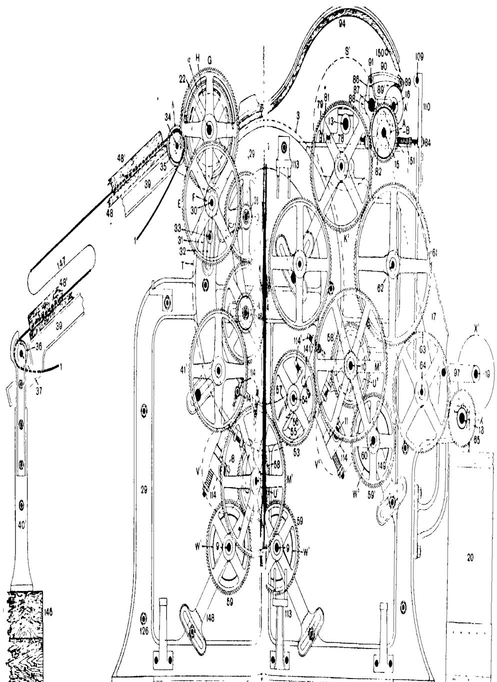


FIG 90

[To face page 170.

drawing-roller into its normal position. Such an arrangement naturally does not admit of the drawing roller block 82 being fixed as customary to the frame; the position of the block with regard to the frame is secured by means of a dovetail on the under-surface of the block, the lips of the dovetail overhanging the edges of the frame as shown.

The method of adjusting the shell 2 is illustrated in Fig. 91,

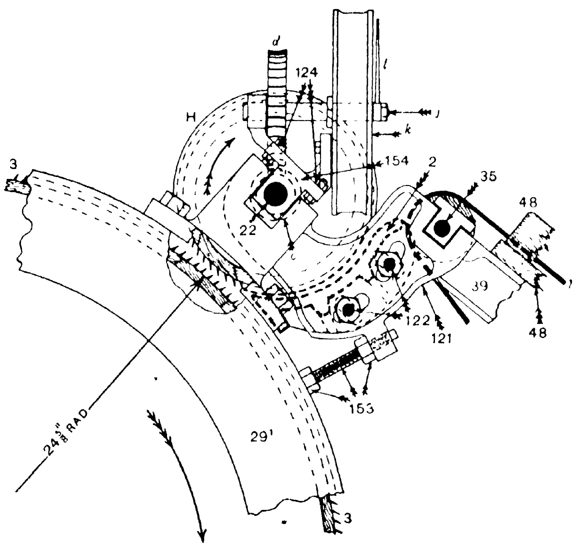


FIG. 91.

and although the parts differ from the corresponding parts of the Lawson machine illustrated in Fig. 73, there is still a similarity in the two. Thus, in Fig. 91 it will be seen that the bracket 121, for supporting the shell 2, is centred on the shaft 22 of the feed roller H, and, when adjusted, is kept in position by the bolt and nuts 153, a similar set being provided at the other side of the machine.

The shell 2 is bolted to the bracket 121 by the bolts and nuts 122; slots are provided to enable the shell to be moved nearer to

or farther from the feed roller H before being fixed by these bolts and nuts. A further set of slots, concentric with the shaft 22, enable the shell to be adjusted roughly with respect to the points of the pins 3 of the cylinder T. The final adjustment of the shell to the cylinder is made by means of the above-mentioned bolt and nuts 153, for, since the bolt passes through a lug in the bracket 121, it follows that both bracket 121 and shell 2 can be moved in either direction.

The feed roller itself can be moved nearer to or farther from the pins 3 of the cylinder T by using the lock-nuts 124 in conjunction with the bushes or bearings 154 in which the shaft 22 of the feed roller H is supported. The upper surface of the bush 154 is prolonged at both ends; one of these projections serves as a support for the clock, while the other supports the end of the spindle shaft *j* of the clock.

Since the lettering and numbering are general in all the breaker cards which are illustrated, it follows that the various calculations will also be similar and in many cases identical. Thus, the draft calculation for the Fairbairn machine is, as in the case of the Lawson machine—

$$(39) \qquad \frac{A \times C \times E \times G}{B \times D \times F \times H} = \text{draft, as in formula (1),}$$

and the actual draft with the wheels and other parts illustrated in Fig. 90 is—

$$(40) \qquad \frac{4 \times 80 \times 110 \times 110}{52 \times 22 \times 20 \times 10{\cdot}75} = 15{\cdot}74 \text{ draft.}$$

Hence the constant number with this particular arrangement of wheels is—

$$(41) \qquad \frac{4 \times 80 \times 110 \times 110}{52 \times 22 \times 10{\cdot}75} = 314{\cdot}8, \text{ say } 315.$$

If, in this case, we assume a speed of 180 revs. per min. of the main cylinder T we have, as in formulæ (10) and (11)—

$$(42) \qquad \text{Revs. of T} \times \frac{J}{B} = \text{revs. per min. of drawing roller A,}$$

and

$$(43) \quad \text{Revs. of T} \times \frac{J}{C} \times \frac{D}{E} \times \frac{F}{G} = \text{revs. per min. of feed roller H.}$$

With numerical values from wheels in Fig. 90 we have—

(44) $180 \times \frac{20}{52} = 69{\cdot}23$ revs. per min. of drawing roller A,

and

(45) $\frac{180 \times 20 \times 22 \times 20}{80 \times 110 \times 110} = \frac{18}{11} = 1{\cdot}636$ revs. per min. of feed roller H;

and again—

(46) $\frac{\text{Surface speed of the drawing roller A}}{\text{Surface speed of the feed roller H}} =$ the draft as in formula (8).

Hence—

(47) $\frac{69{\cdot}23 \times 4 \text{ in.} \times 3{\cdot}1416}{1{\cdot}636 \times 10{\cdot}75 \text{ in.} \times 3{\cdot}1416} = 15{\cdot}74$ draft.

It is obvious that with the adoption of the two small change pinions J and F the speeds of the feed roller H and the drawing roller A are slow when compared with the corresponding roller speeds found on pp. 140 and 146, and the draft, although not uncommon; is much higher than that found in connection with the parts illustrated in the Lawson machine. It must be remembered, however, that in Fig. 90 we have introduced the smallest change pinion F, and the smallest cylinder change pinion J from the usual set supplied for this machine. Smaller pinions still, however, are provided if required; thus, if it were found advantageous to have a longer draft one might use a smaller pinion F and, or, a larger compound wheel E. The general plan would be to use a smaller pinion F.

In Fig. 90 the pinion F contains 20 teeth; hence, considering this, as well as the pinion J as the smallest pinion in stock, it follows that the arrangement illustrated in this figure would result in a minimum speed of the feed roller H, and also, of course, a minimum speed of the drawing roller A.

From what has been said in connection with the calculations for the Lawson machine it is evident that the constant numbers are exceedingly useful for finding the correct wheels quickly for any desired simple change. Thus, suppose that instead of the above draft of 15·74 in formulæ (40) and (47) it was desired to use the same draft as in the formula (3)—that is, 11·72. Then it would

simply be necessary to divide the constant number in formula (41) by this draft, and we have—

$$(48) \qquad \frac{315}{11 \cdot 72} = 26 \cdot 87;$$

say, 26 or 27 tooth pinion at F; and by a corresponding alteration in formula (45) we should have—

$$(49) \qquad \frac{180 \times 20 \times 22 \times 27}{80 \times 110 \times 110} = 2 \cdot 209 \text{ revs. per min. of the feed roller H.}$$

(These values are taken to two or three places of decimals for the sake of making the various theoretical values as accurate as possible; in practice, it would be ridiculous to consider such apparent accuracy in speed.) Hence the surface speed of the feed roller H would be—

$$(50) \qquad \frac{2 \cdot 209 \times 10 \cdot 75 \text{ in.} \times 3 \cdot 1416}{12 \text{ in. per foot}} = 6 \cdot 217 \text{ ft. per min.}$$

Now, this speed is considerably less than that of 11·31 found in the table of speeds, p. 140. Consequently, although the draft is the same, the speed is low, and the production, so far as weight is concerned, might be considered unsatisfactory.

Suppose, however, that the above speed of 11·31 ft. per min. of the feed roller H is suitable, not only for the operative, but also for the production; then, with this speed and a draft of 11·72, it is easy to find the speed of the drawing roller A. Thus—

$$(51) \qquad 11 \cdot 31 \text{ ft. per min.} \times 11 \cdot 72 \text{ draft} = 132 \cdot 5532,$$

or practically the same as 132·64 found in the above table of speeds, p. 140.

It would now be necessary to find the number of teeth in the cylinder change pinion J, which, as we know, see formulæ (10) and (42), affects the speed of the drawing roller A.

$$(52) \qquad \text{Revs. of T} \times \frac{J}{B} = \frac{132 \cdot 64 \times 12 \text{ in. per foot}}{4 \text{ in.} \times 3 \cdot 1416}.$$

$$(53) \qquad \text{Hence } J = \frac{132 \cdot 64 \times 12 \times B}{4 \times 3 \cdot 1416 \times T}$$

$$= \frac{132 \cdot 64 \times 12 \times 52}{4 \times 3 \cdot 1416 \times 180}$$

$$= 36 \cdot 59, \text{ say 36 or 37 teeth.}$$

It is not often that one finds it necessary to consider at the same time the speeds of the feed and drawing rollers and the draft. The more practical case is that of considering a certain production per day and a suitable weight of sliver, together with the essential condition of keeping every machine in the complete set or system fully occupied. This important phase of the work shall be considered shortly. In the meantime, the speeds of the other rollers in Figs. 89 and 90 shall be considered.

As in formula (15), the speed of the worker, the first worker in this machine, is found as under :—

(54) Revs. of T $\times \frac{J}{K} \times \frac{L}{M}$ = revs. per min. of the first worker

(the letters for the worker wheels in Fig. 90 are M^1 and M^2); and since the second worker wheel M^2 is driven from the first worker, wheel M^1 through the intermediate wheel 53, it follows, and naturally, that both workers rotate at the same speed. One must not lose sight of the fact that an alteration of the cylinder change pinion J alters the relation between the speeds of the cylinder and the worker; hence, if the cylinder pinion J is changed, it would be necessary to substitute another change pinion at L in order that the proper amount of carding may take place.

The surface speed of the cylinder T, at 190 revs. per min., is 2459·10 ft. per min. (see the table of speeds on p. 140). In the same table the speed of the worker is given at 32·26 ft. per min.

The speed of the cylinder, at 180 revs. per min., would therefore be—

(55) $$2459{\cdot}10 \times \frac{180}{190} = 2329{\cdot}67 \text{ ft. per min.}$$

(see above remark about accuracy of speeds); and to preserve the same relative speed, the worker should be reduced proportionately—that is, if these speeds are considered to be satisfactory. Hence—

(56) $$32{\cdot}26 \text{ ft.} \times \frac{180}{190} = 30{\cdot}56 \text{ ft. per min. of the worker } W';$$

and since—

(57) $$\frac{\text{Revs. of } W' \times \text{diameter of } W' \times 3{\cdot}1416}{12 \text{ in. per foot}}$$

$= 30{\cdot}56$, the surface speed of the worker,

we have—

$$(58) \qquad \frac{30{\cdot}56 \times 12 \text{ in.}}{\text{Diameter of } W' \times 3{\cdot}1416} = \text{revs. of worker } W'.$$

$$(59) \qquad \frac{30{\cdot}56 \times 12}{8{\cdot}5 \times 3{\cdot}1416} = 13{\cdot}73 \text{ revs. per min. of } W'.$$

Now—

$$(60) \qquad \frac{\text{Revs. of } T \times J \times L}{K \times M} = \text{revs. per min. of } W' = 13{\cdot}73.$$

Hence, when the cylinder change pinion J is decided upon, say 36 teeth as in formula (53), and not 20 teeth as illustrated in Fig. 90, we have—

$$(61) \qquad \frac{180 \times 36 \times L}{90 \times 138} = 13{\cdot}73,$$

consequently—

$$\frac{180 \times 36}{90 \times 138} L = 13{\cdot}73,$$

$$\therefore \quad \frac{12}{23} L \text{ or } 0{\cdot}5217 \, L = 13{\cdot}73,$$

where 0·5217 is a constant number; hence, L in the case under notice is—

$$(62) \qquad \frac{13{\cdot}73}{0{\cdot}5217} = 26{\cdot}31, \text{ say 26 teeth.}$$

The stripper pulley N, on the cylinder shaft 4, Fig. 89, is 14 in. in diameter, and the stripper pulleys O^1 and O^2, on the shafts 8 and 11, are 20 in. in diameter. Hence, the speed of the strippers V^1 and V^2 is—

$$(63) \quad \text{Revs. of cylinder } T \times \frac{\text{diameter of N}}{\text{diameter of O}} = \text{revs. per min. of strippers}$$

—*i. e.*,

$$(64) \quad 180 \times \frac{14}{20} = 126 \text{ revs. per min. of strippers } V^1 \text{ and } V^2.$$

The working diameter of the strippers V^1 and V^2 is 12½ in.; hence the surface speed of these is—

$$(65) \quad \frac{126 \times 12{\cdot}5 \text{ in.} \times 3{\cdot}1416}{12 \text{ in. per foot}} = 412{\cdot}335 \text{ ft. per min.}$$

as compared with a speed of 470 ft. per min. in the above table on p. 140, for the strippers in the Lawson machine with a speed of 190 revs. per min. of the cylinder.

The doffing roller S′ is driven as usual from the drawing roller A, Fig. 89; hence—

(66) $\text{Revs. of A} \times \frac{P}{Q} \times \frac{R}{S}$ = revs per min. of the doffing roller S′.

We have already fixed the surface speed of the drawing roller A as 132·64 ft. (see formula (51)); hence—

(67) $\frac{132\cdot 64 \text{ ft.} \times 12 \text{ in.}}{A \times 3\cdot 1416} \times \frac{P}{Q} \times \frac{R}{S}$ = revs. per min. of the doffing roller S′

—*i. e.*,

(68) $\frac{132\cdot 64 \text{ ft.} \times 12}{4 \times 3\cdot 1416} \times \frac{24}{54} \times \frac{28}{116}$ = 13·59 revs. per min. of S′.

Therefore, with an 18 in. doffing roller, with $19\frac{1}{2}$ in. working diameter, we have—

(69) $\frac{19\frac{1}{2} \text{ in.} \times 3\cdot 1416 \times 13\cdot 59}{12 \text{ in. per foot}}$ = 69·36 ft. per min. of the 18 in. doffing roller;

and—

(70) $\frac{132\cdot 64 \text{ ft.}}{69\cdot 36 \text{ ft.}}$ = 1·91 of a draft between the drawing roller A and the doffing roller S′.

As already mentioned, a clock somewhat similar to that illustrated in Figs. 73 and 75 is provided with each breaker card to enable the feeder to distribute the weighed and fixed quantity of jute as evenly as possible on the feed sheet 1. In all cases, the clock is driven from the feed-roller shaft, but slight differences obtain in the arrangement of the gearing from this shaft to the clock spindle. For the purpose of illustrating more clearly the details of the mechanism, we introduce two typical kinds of clocks.

Figs. 92 and 93 illustrate respectively a front and an end elevation of the clock and gearing as supplied with the Fairbairn card illustrated in Figs. 87 to 90. In order that the mechanism and its relation to the machine proper may be easily followed, part of the staves of the feed roller H and the cylinder T, with their respective pins, have been added. The direction of motion of the cylinder T on the driving shaft 4, and also that of the feed roller H on the shaft 22, are indicated by arrows, and all these parts are in their respective relative positions.

On the end of the shaft 22 is a triple-thread worm *c* which drives directly a worm-wheel *d* of 42 teeth on the shaft of the clock spindle *j*. The hand *l* is fixed to this spindle, and naturally moves slowly and uniformly over the face *k* of the clock.

The "clock length" denotes the length of material or the length of stricks which is carried forward by the feed roller during

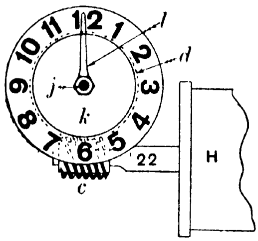


FIG. 92.

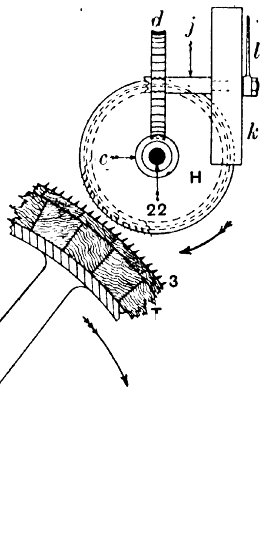


FIG. 93.

the time that the hand *l* of the clock makes one complete revolution. The calculation for this "clock length" is made as follows:—

$$\text{(71)} \qquad 1 \text{ rev. of clock hand} \times \frac{d}{c};$$

or—

$$1 \times \frac{42}{3} = 14 \text{ revs. of H.}$$

The feed roller H is 10·75 in. in diameter at the working position; hence—

$$\text{(72)} \qquad \frac{14 \times 10{\cdot}75 \text{ in.} \times 3{\cdot}1416}{36 \text{ in. per yard}} = 13{\cdot}13 \text{ yds. or the clock length.}$$

The clock and gearing for the Low breaker card are illustrated in Figs. 94 and 95. On the feed-roller shaft 22 is a spur-wheel *m* of 26 teeth which drives a similar wheel *n*, also of 26 teeth, on the worm-shaft *o*. A double thread worm or screw *c* drives the worm-wheel *d* of 24 teeth on the vertical shaft *p*, while two bevel-wheels *q* and *r*, of 18 teeth each, complete the gearing to the clock spindle *j*, to which is attached, as usual, the hand *l*.

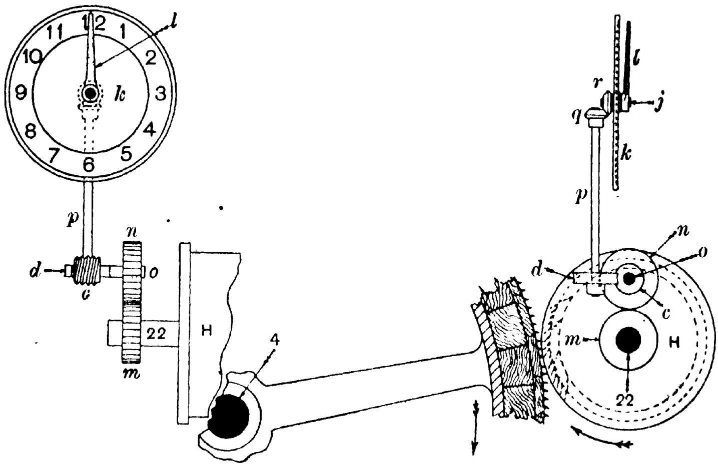


FIG. 94. FIG. 95

The clock length is found as before—

$$(73) \qquad 1 \text{ rev. of clock hand} \times \frac{r}{q} \times \frac{d}{c} \times \frac{n}{m};$$

or—

$$1 \times \frac{18}{18} \times \frac{24}{2} \times \frac{26}{26} = 12 \text{ revs. of H};$$

and—

$$(74) \qquad \frac{12 \times 11{\cdot}625 \text{ in.} \times 3{\cdot}1416}{36 \text{ in. per yard}} = 12{\cdot}17 \text{ yds. the clock length.}$$

These examples demonstrate the method of calculating the clock length; they also demonstrate the different methods of conveying the desired motion from the feed-roller shaft 22 to the hand of the clock.

CHAPTER XI

CALCULATIONS ON PRODUCTION AND COMPARISON OF BREAKER CARDS

It is quite clear that the number of numerical examples in connection with the breaker card could be largely multiplied, but this would serve no good purpose. There is one very important phase, however, connected with the work which cannot wisely be omitted—viz., that of considering the actual production from a given arrangement of breaker cards with respect to the subsequent machinery, and for this purpose we shall consider two well-defined methods of grouping the breaker cards with the finisher cards; the latter machines will be described and illustrated shortly.

The first grouping is that in which two breaker cards work in conjunction with, and supply sliver for, three finisher cards. The second grouping is that in which one breaker card supplies sliver for two finisher cards.

It should be stated at once that there is no absolute rule as to the quantity of material which should be run through one machine in a given time; there may be, and probably is, a limit to the weight which can be safely passed through per day, and also to the speed per minute at which the machine may be driven. Whatever weight of material is treated, however, it is absolutely essential that every strick should receive the necessary amount of carding, or otherwise the finished yarn will be inferior to what it would be if the carding were satisfactorily performed. Faults created or work imperfectly conducted in one machine cannot be remedied thoroughly in any subsequent machine. Nevertheless, it is desirable for obvious reasons to keep the production at a maximum consistent with fair treatment to the machinery and material involved. And it need hardly be stated that the type or quality of the finished yarn influences both the speed and the production. No quality is mentioned at present, nor is it desirable, and no allowance is

made for any loss or waste at present, hence we shall assume that each finisher card is desired to treat 27 cwt. of jute sliver per day, and that the finisher cards use up all the material which is delivered from the breaker cards.

If two breaker cards supply each of the three finisher cards with 27 cwt., each of the two breaker cards must treat—

(75) $$\frac{27 \times 3}{2} = \frac{81}{2} = 40\tfrac{1}{2} \text{ cwt. of fibre per day;}$$

whereas if one breaker card provides sliver for two finisher cards, the breaker card must deliver—

(76) $$27 \times 2 = 54 \text{ cwt. of fibre per day.}$$

Let us consider the first case, where $40\frac{1}{2}$ cwt. per day is delivered by each breaker card, and that the sliver delivered is required to weigh 17 lb. for each 100 yds.

(77) $$40\tfrac{1}{2} \text{ cwt.} \times 112 \text{ lb. per cwt.} = 4536 \text{ lb.}$$

(78) $$\frac{4536 \text{ lb.}}{17 \text{ lb. per } 100 \text{ yds.}} = 266{\cdot}82 \text{ lengths of } 100 \text{ yds each per day;}$$

and—

(79) $$266{\cdot}82 \times 100 \text{ yds. each} = 26{,}682 \text{ yds. of sliver per day,}$$

(80) $$\frac{26{,}682 \text{ yds. of sliver}}{600 \text{ mins. per day}} = 44{\cdot}47 \text{ yds. per min., or } 1600{\cdot}92 \text{ in. per min.}$$

(81) Diameter of A $\times$ 3·1416 = circumference of drawing roller A; $4 \times 3{\cdot}1416 = 12{\cdot}5664$ in. circumference;

hence—

(82) $$\frac{1600{\cdot}92 \text{ in. of sliver}}{12{\cdot}5664 \text{ in. circumference of A}} = 127{\cdot}397, \text{ say } 127, \text{ revs. per min. of drawing roller A.}$$

If the speed of the cylinder is 180 revs. per min., then—

(83) $$180 \times \frac{J}{52} = 127 \text{ revs.} \quad \text{(See formula (42).)}$$

(84) $$\therefore \; J = \frac{127 \times 52}{180} = 36{\cdot}7, \text{ say } 37, \text{ teeth for the change pinion J.}$$

In the second case, where one breaker card supplies 54 cwt. of sliver for two finisher cards, the figures are as under:—

(85) $54 \text{ cwt.} \times 112 \text{ lb. per cwt.} = 6048 \text{ lb.}$

(86) $\dfrac{6048}{17 \text{ lb. per } 100 \text{ yds.}} = 355{\cdot}76$ lengths of 100 yds. each per day;

and

(87) $355{\cdot}76 \times 100 = 35{,}576$ yds. of sliver per day.

(88) $\dfrac{35{,}576 \text{ yds.}}{600 \text{ mins. per day}} = 59{\cdot}2$ yds. per min., or $2134{\cdot}44$ in. per min.

(89) $\dfrac{2134{\cdot}44 \text{ in.}}{12{\cdot}5664 \text{ in. circumference of A}}$
$= 169{\cdot}85$ revs. per min. of the drawing roller A.

If, for this example, we assume a speed of 200 revs. per min. of the cylinder, then, since—

(90) $$200 \text{ revs.} \times \frac{J}{52} = 169{\cdot}85,$$

$J = \dfrac{169{\cdot}85 \times 52}{200} = 44{\cdot}16$, or 44, teeth for the cylinder change pinion J.

It has already been pointed out that there are two systems of regulating the weight of jute which is fed on to the feed sheets of breaker cards:—

(*a*) That where the fibre is weighed before it is delivered to the breaker card; and

(*b*) That where the fibre is usually fed into the machine without being weighed, because several of the resulting slivers are to be made into a ball or lap. Nevertheless, it is often considered an advantage to weigh the fibre even for this system.

When weighing is practised, a fixed weight of fibre, termed the "dollop weight" or "dollop bundle," is used for each complete revolution of the clock-hand. A pair of scales is suspended in a suitable position, and weights equal to the weight of the dollop bundle are placed inside a box. The bulk of the weight is often in the form

of a block of lead. The box is locked, and the key is kept by the manager of the mill, since it is imperative that no unauthorised person should be able to interfere with the weight. One end of a cord is fixed to the weighted end of the scale, and the other end of the cord is attached to a convenient place on the wall; this is obviously to prevent undue movement of the beam under all conditions.

When the "dollop weight" has been calculated and fixed, as will be shown immediately in formulæ (93) and (95), and the necessary small weights have been added to the leaden block to make up the exact weight, the work proceeds. The fibre is transferred to the scales from a barrow conveniently placed near them. The "dollop bundle" is then removed from the scale-pan, and placed in one of two shallow, but raised, wooden stalls or compartments. The attendant at the breaker card uses the fibre from one stall while the weigher is getting another dollop bundle ready for the other stall, and so the work goes on.

The dollop bundle has to be spread as evenly as possible on the feed sheet, and the whole used up while the clock-hand makes one revolution. And, since the "clock length" in connection with the Fairbairn machine is 13·13 yds., and the draft is, say, 15·74 as in formula (40), we have—

(91) Draft × clock length = the length of sliver per round of the clock.

(92) ∴ 15·74 × 13·13 = 206·6662, say 206·7, yds. of sliver in clock length.

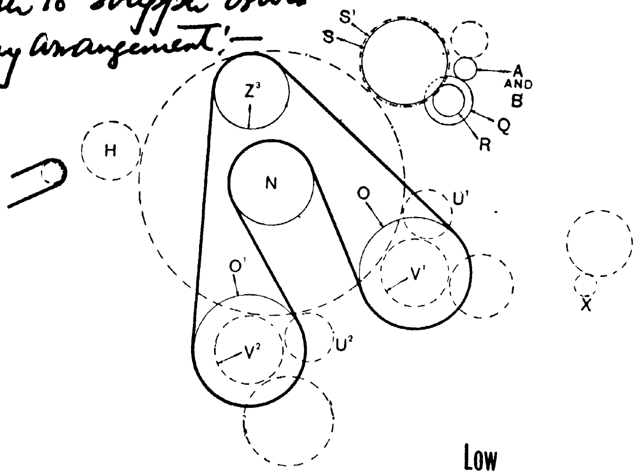
Hence, since 100 yds. of sliver must weigh 17 lb. in this particular case, it follows that—

(93) $\frac{17 \text{ lb.} \times 206 \cdot 7 \text{ yds.}}{100 \text{ yds.}} = 35 \cdot 16$, say 35 lb., or $35\frac{1}{4}$ lb., dollop weight.

For reasons which will be stated later, the weight used is usually more than the calculated weight. With a draft of 11·72 as in the other case, and the same clock length, we have—

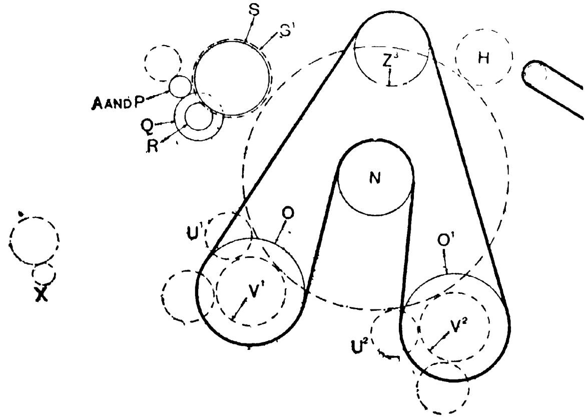
(94) 11·72 × 13·13 = 153·8836, say 154, yds.

Cylinder to stripper drive
Pulley arrangement:—



Low

FIG. 96



Fairbairn

FIG. 97.

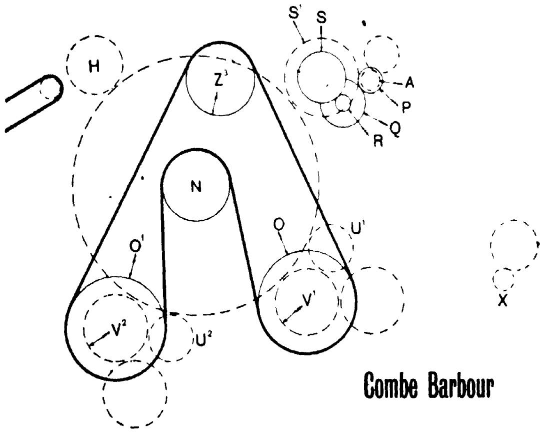

S'
S
A
P
Q
R
H
Z³
N
O
U'
O'
V²
V'
U²
X
Combe Barbour

Fig. 98.

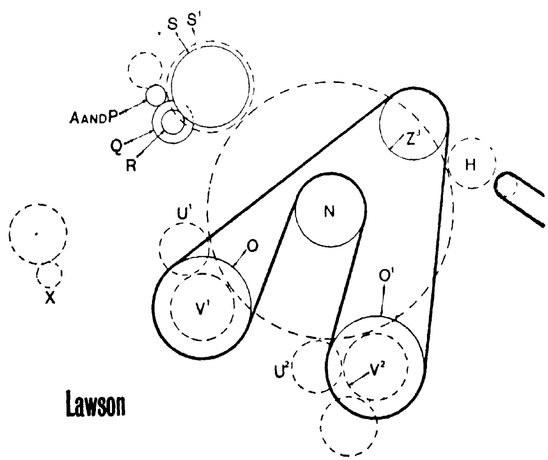

S
S'
A AND P
Q
R
Z³
H
N
U'
O
O'
V'
X
U²
V²
Lawson

Fig. 99

and—

$$(95) \qquad \frac{17 \text{ lb.} \times 154 \text{ yds}}{100 \text{ yds.}} = 26{\cdot}18 \text{ lb. dollop weight.}$$

For similar calculations with regard to other machines, it would clearly be necessary to substitute the particular clock length of such machine for that of 13·13 used in the above two examples.

Since the operation of carding must necessarily be the same, or practically the same, in all the different types of breaker cards for carding the same or similar long vegetable fibres, it is unnecessary to introduce elaborate drawings and descriptions of the individual breaker cards made by the various machine makers. In order, however, to provide facilities for comparative purposes and for ease in making the various calculations, we introduce Figs. 96 to 105.

Fig. 96 represents the pulley side of the breaker card made by Messrs. James F. Low & Co. Ltd., while Figs. 97, 98, and 99 represent the pulley sides of the three machines made by Messrs. Fairbairn Lawson Combe Barbour Limited. The machines are distinguished by the four names—Low, Fairbairn, Combe Barbour, Lawson. Figs. 100 to 103 illustrate the gear sides of the same four machines with similar identification names. Figs. 104 and 105 illustrate in a similar manner the pulley side and the gear side of the machine made by Messrs. Douglas Fraser and Sons Limited.

In all these five machines the lettering and numbering are consistent—that is, all wheels, rollers, etc., which have the same name, and which fulfil the same function as those illustrated in Figs. 72 to 75 and Figs. 87 to 90, receive the same letter or number. In the first place, such a set of skeleton drawings as those shown in Figs. 96 to 105 enable the student or the practical man to locate any given part for calculation purposes or reference; and, in the second place, the drawings show at a glance the disposition of the various wheels and rollers, and thus offer a ready and valuable means of comparison. The intermediate wheels have not been lettered or numbered, partly because the number of such wheels varies in the different machines, and partly because it is unnecessary to include them in the calculations. As a further and necessary aid to the calculations, we append a list of all the essential wheels and rollers, with the number of teeth in each wheel, and the diameter of each roller, in all the machines illustrated in Figs. 71 to 105.

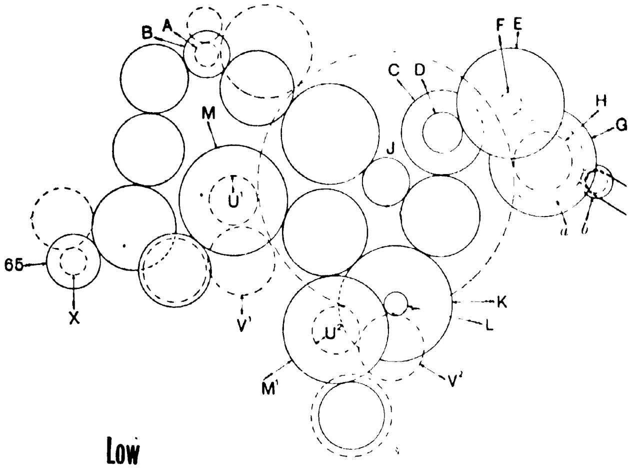


FIG. 100.

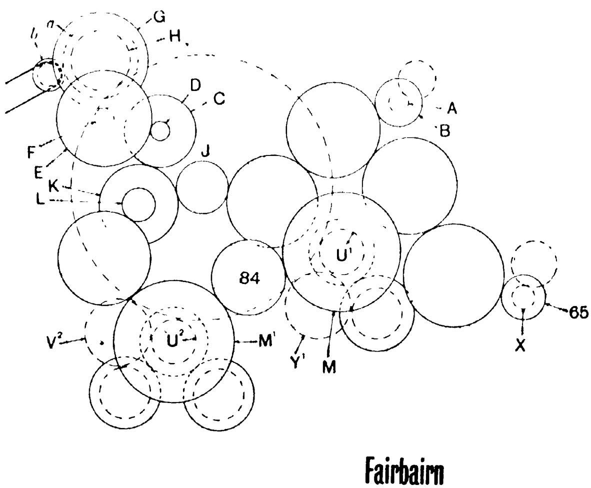


FIG. 101.

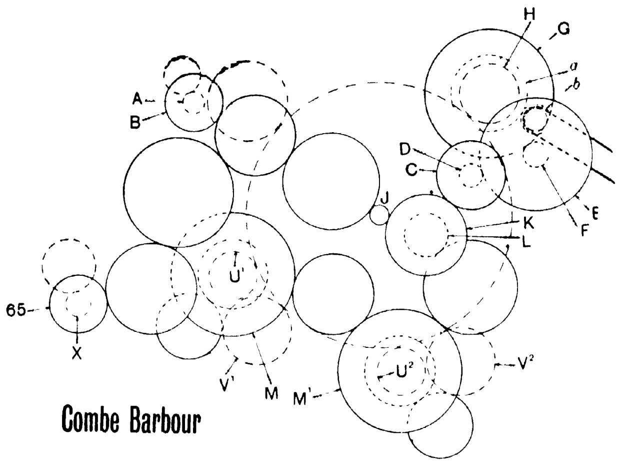


FIG. 102.

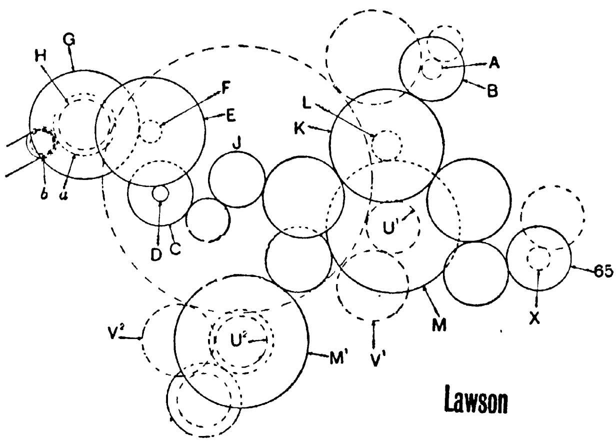


FIG. 103.

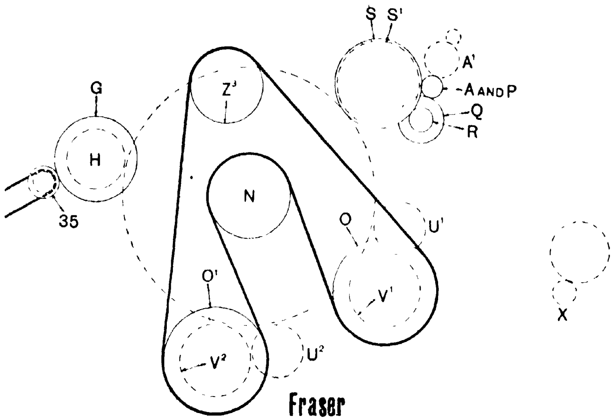


FIG. 104.

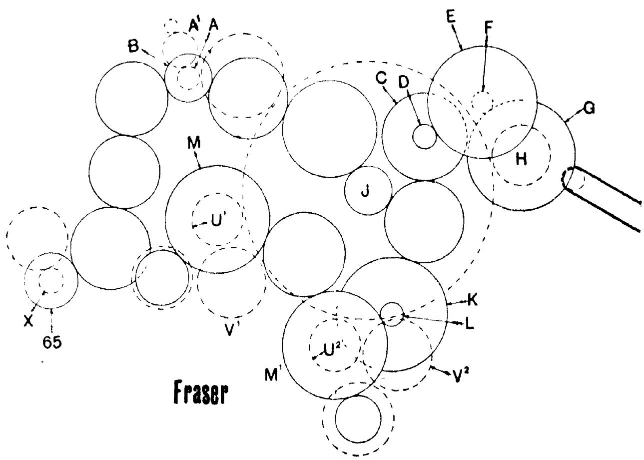


FIG. 105.

In some cases compound wheels are used along with the worm *c* and the worm-wheel *d*; when these wheels have any effect upon the calculation they are mentioned along with the worm-wheel *d* in the table.

Letter or Number.	Low.	Fairbairn.	Combe Barbour.	Lawson.	Fraser.
A	4 in. diam.	4 in diam.	4 in diam.	4 in. diam.	4 in. diam.
B	52	52	52 or 64	72	50
C	96	80	80	72	96
D	20 to 38	20 to 60	22 to 44	18	20 to 38
E	130	110	128	120	130
F	24	20	20	20 to 28	24
G	130	110	100	120	130
H	10 in. diam.	9 in diam.	10 in diam.	8 in. diam.	10 in diam.
J	48 to 60	20 to 60	22 to 60	30 to 60	48 to 60
K	130	90	90	130 or 150	130
L	24	20 to 60	20 to 36	28 to 36	25
M^1 & M^2	124	138	138	150	124
N	16 in diam.	14 or 16 in. diam.	14 in diam.	14 in. diam.	16 in diam.
O	21 in diam.	18 or 20 in. diam.	18 in diam.	20 in. diam.	20 in. diam.
P	24	24	30	24	24
Q	54	54	55	48	56
R	32	28	20	25	28
S	102	88 116	60 or 64	96	104
S^1	16 in. diam.	14 in. diam. 18 in. diam.	14 in diam.	14 in diam.	16 in. diam.
T	48 in diam.	48 in. diam.	48 in diam.	48 in. diam.	48 in diam.
U^1 & U^2	7½ in diam.	7½ in diam.	7 in diam	7½ in diam.	8 in. diam.
V^1 & V^2	12 in. diam	11 in. diam.	11 in diam.	12 in. diam.	12 in. diam.
X	5 in diam.	4 in. diam.	4⅛ in diam.	4¼ in. diam.	4½ in. diam.
Y & Y^1	24–30 in diam.	24–30 in. diam.	24–30 in diam.	24–30 in diam.	24–30 in diam.
Z^2	14 in. diam.	14 in. diam.	14 in diam.	14 in diam.	14 in. diam.
a	95	114	88	66	95
b	35	46	32	33	35
c	2-thread.	3-thread.	3-thread.	2-thread.	1-thread.
d	24	42	42	60 with $\frac{44}{33}$	24 with $\frac{18}{24}$
65	60	51	52 or 64	72	64

CHAPTER XII

LAP OR BALLING MACHINES

It has already been stated that there are two different and widely practised methods of feeding the finisher cards by the slivers which have been made in the breaker cards. In one system, ten or twelve cans, each filled with a continuous length of sliver, are taken to the feed side (front) of the finisher card, while in the other method a number of these slivers from the breaker card are wound into what is termed a " ball " or " lap," and the finisher card is then fed with two or three of these laps.

With the balling or lap system of feeding it is unusual to employ a clock at the breaker card; but, on the other hand, it is sometimes considered advisable to retain the clock and dollop system in conjunction with lap feeding. The latter practice is, however, usually the outcome of local circumstances; when adopted it constitutes an extra advantage and check if the work is performed satisfactorily. In some mills both systems are in use—the direct feeding from the cans being adopted where both the breaker and finisher cards are in the same room or flat, and the lap system utilised where the two types of machines happen to be in separate rooms or flats. It is obvious, however, that in most up-to-date establishments the two sets of machines are housed in the same room, and near to each other, as is exemplified in the mill plan in Fig. 28, page 44.

Lap or balling machines are made for winding four, five, or six slivers on to each pin, and the width of the pins may be sufficient to make laps suitable for—

(*a*) Two in the width—*i. e.* 30 in. each; or
(*b*) Three ,, ,, —*i. e.* 20 in. ,,

or a combined width of 60 in. in both cases, according to the require-

FIG 106.

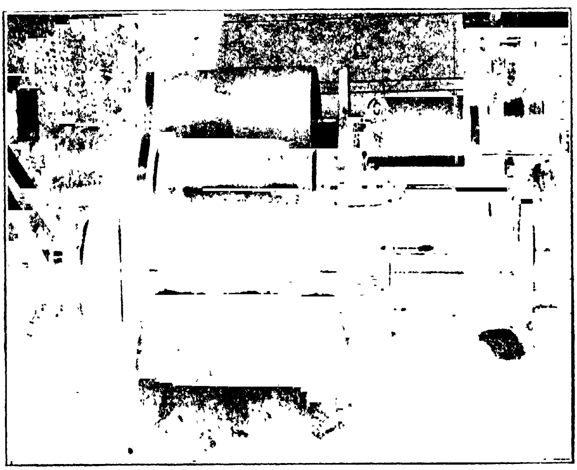


FIG. 107.

ments of the finisher card and other circumstances. Thus each set for the width of the card may contain—

2 balls, each of	4 slivers	—	8 slivers per set.
3 ,, ,,	4 ,,	—	12 ,, ,,
2 ,, ,,	5 ,,	—	10 ,, ,,
3 ,, ,,	5 ,,	—	15 ,, ,,
2 ,, ,,	6 ,,	—	12 ,, ,,
3 ,, ,,	6 ,,	—	18 ,, ,,

In every case, however, each ball contains 100 yds. of each sliver.

One type of lap machine, made by Messrs. Fairbairn, Leeds, is illustrated in Figs. 106 to 114, and is arranged for winding on six slivers at a time. Figs 106 and 107 show general views of the end opposite to the driving and the delivery side of the same machine. In both illustrations is shown a pin filled with the combined slivers, and in Fig. 107 there are several filled pins in the background on

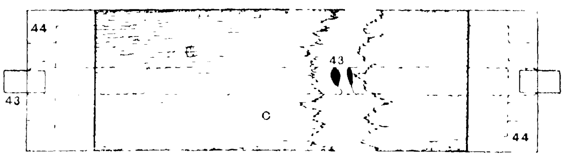


FIG. 108

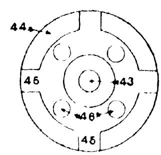


FIG 109.

the left, while Fig. 108 shows details of an empty pin. The complete pin is either 21 in. or 31 in. long by 3½ in. diameter. The central part is usually made of beech, and a ⅝ in. rod 43, Figs. 108 and 109, screwed at both ends is inserted. Two cast-iron caps 44 are screwed on the ends of the rod, and the extreme ends of the rod reduced to ½ in. diameter to fit the stands in the frame of the finisher card and the holes in the flanges O and P, Fig. 110. Each cap 44 is made as illustrated in the end view in Fig 109, and contains four recesses 45 near its periphery, by means of which it is driven by suitable keys on the flanges O and P. The four circular holes 46, nearer the centre of the cap, are made so that holes may be drilled into the wood; these holes are filled or partially filled with lead, if necessary, to make all the pins a uniform weight.

Figs. 110 and 111 are elevations respectively of the delivery side and the feed side. The ordinary fast and loose pulleys A and B are provided, but these are not used in the general way which obtains

for such, since it is essential that some kind of differential drive should control the winding on of the slivers in order that the latter

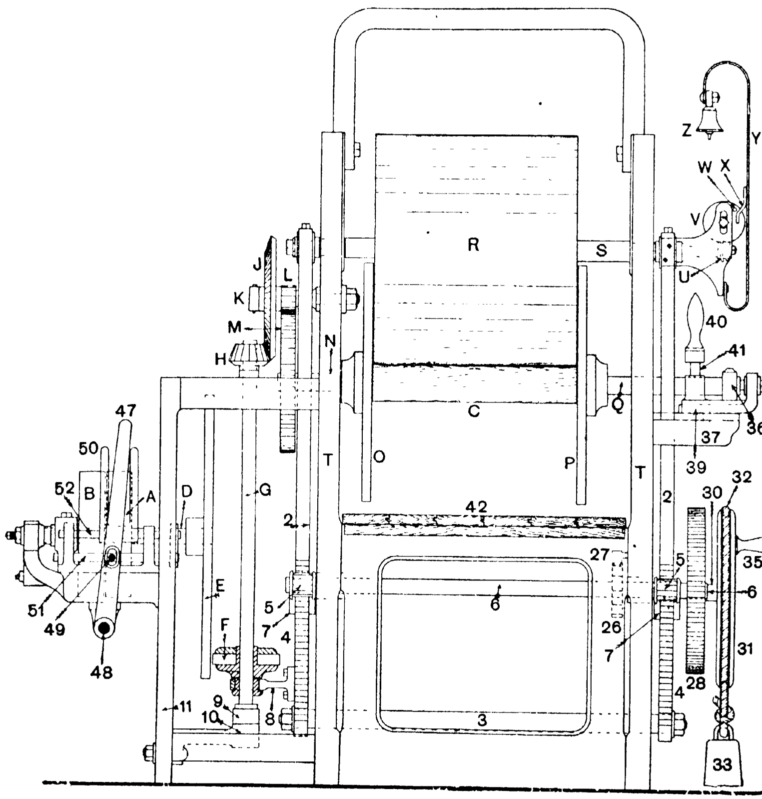


FIG. 110.

may run on to the pins C at a uniform surface speed throughout. Hence, the belt is allowed to remain constantly on the fast pulley A on the shaft D, upon which is fixed the friction plate E. The friction plate is therefore in constant rotation even when the machine,

for short periods, is inoperative. To start the machine it is necessary to bring the leather-faced friction bowl F into contact with the friction plate E; when this is done, the upright shaft G will be set in motion. The friction plate E and the bowl F are clearly seen in Fig. 107. A bevel pinion H of 16 teeth on the upper end of the shaft G, Fig. 111, communicates the motion to the bevel-wheel J of 60 teeth on the stud K. Compounded with the wheel J, on the same stud K, is a spur pinion L of 12 teeth, which drives the wheel M of 84 teeth on the pin shaft N. Fixed to the shaft N is a flange O, while a similar flange P is secured to the shaft Q, both P and Q being capable of being slid a distance of about 2½ in. to enable the pins C to be inserted, and the filled laps to be removed.

When the machine is in operation, the two flanges O and P are respectively in close contact with the two ends of the pin C, while between the flanges O and P, and in contact with the pin C when the latter is empty, or with the slivers when the pin is partially or wholly filled, is a pressing and measuring roller or drum R of 72 in. circumference on the shaft S. The shaft S projects, as shown, through the two side frames T. At one extreme end of the shaft S is a worm U, which gears with and drives the worm-wheel V. Projecting from the face of this worm-wheel V is a pin W which, at every revolution of the wheel, comes into contact with a small spring X attached to the main-bell spring Y, and to the upper bend of the latter is attached the warning bell Z. The object of this apparatus is to warn the attendant when the above-mentioned length of 100 yds. of each sliver has been wound on to the pin C.

Carried by the shaft S, Figs. 110 and 113, and outside the main frames T, are two connecting arms 2 which join the shaft S to the stout rod 3; this rod 3 is sometimes weighted in order to give additional pressure between the drum R and the roll or lap of slivers. On the face of these connecting arms 2 are fixed the racks 4, which are in gear with the two pinions 5 on the shaft 6; while on the opposite side to the pinions 5 are two anti-friction rollers 7 in close contact with the backs of the two connecting arms 2. These anti-friction rollers serve to keep the racks 4 in gear with the pinions 5. The end of a bracket 8, projecting from the lower end of the connecting arm 2 on the driving side, encircles the lower part of the leather-faced friction bowl F, which in Fig. 110 is obviously clear of the

friction plate E. A short lever 9, Figs. 110 and 112, fulcrumed at 10, extends outside the supplementary frame 11, and the end

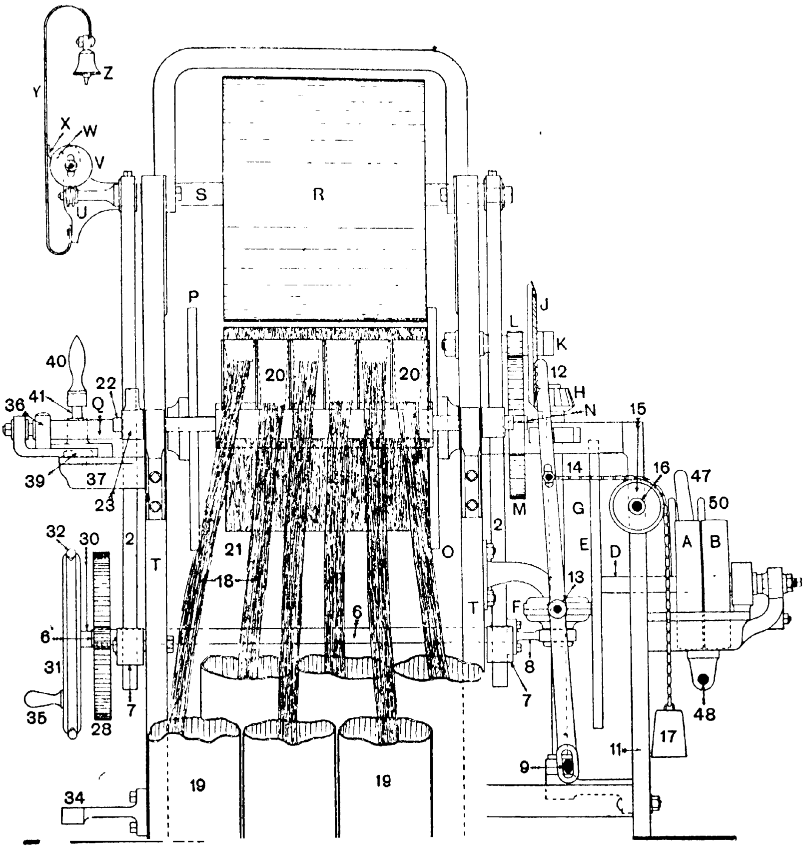


FIG. 111.

of the long arm of this lever 9 passes through a slot in the lower end of the set-on handle 12, Fig. 111, fulcrumed at 13. A chain 14, Figs. 111, 112, and 114, is attached to the set-on handle 12, and then passes over a guide-pulley 15 on stud 16; a weight 17 at the end of

the chain 14 provides and maintains the necessary amount of pressure to enable the friction plate E to rotate the leather-faced friction bowl F, and thus to drive the subsequent mechanism to the pin shaft N.

Let us assume that the six slivers 18 from the sliver cans 19—the latter shown broken in Fig. 111 for the sake of clearness, but complete in Figs. 106, 112, and 113—have been placed in the sliver guides 20, and that their ends have been inserted between the pin C and the pressing drum R, and guided round the pin C as illustrated in Fig. 107. This view shows that a full pin or lap has just been taken from the machine, and all is ready for the machine to commence to fill the newly inserted pin. In Fig. 111 the set-on handle 12 is in the off position, but if the upper end of this handle is moved to the right, its lower end, and also the long arm of the lever 9, will be moved to the left; as a consequence the short arm of the lever 9, Fig. 112, will cause the leather-faced friction bowl F to come into contact with the friction plate E, and at that distance from the centre of the friction plate E indicated in Figs. 106, 110, and 112. Hence the friction bowl F and all parts up to and including the pin shaft N will be put in motion. Immediately this happens, the six slivers Figs. 106 and 111 will be drawn into the machine, and the six slivers, being already round the pin C, Fig. 107, will by surface contact, continue to augment the contents of the pin.

Now every revolution of the pin shaft N will, as already indicated, cause an extra layer of six slivers to be wound on the pin C, and will therefore increase the combined diameter of the pin and slivers; at the same time the pressing drum R will be raised by the increase in the radius of the combined pin and slivers. Consequently, the connecting arms 2, the bracket 8, and the leather-faced friction bowl F, Figs. 107, 110, and 111, will be raised simultaneously with, and through the same height as, the drum R. This will clearly alter the speed of the friction bowl F, since it will now be driven by a smaller diameter of the friction plate E. Thus, as the pin C is being gradually filled by the addition of layer upon layer of the six slivers, the leather-faced friction bowl F, which, when the pin is empty, is near the periphery of the friction plate E, as shown in Fig. 107, is gradually approaching the centre of the friction plate, and is, in consequence, being driven by a gradually decreasing

diameter of the friction plate E. The number of revolutions per minute of the partially filled pin or lap therefore decreases as the

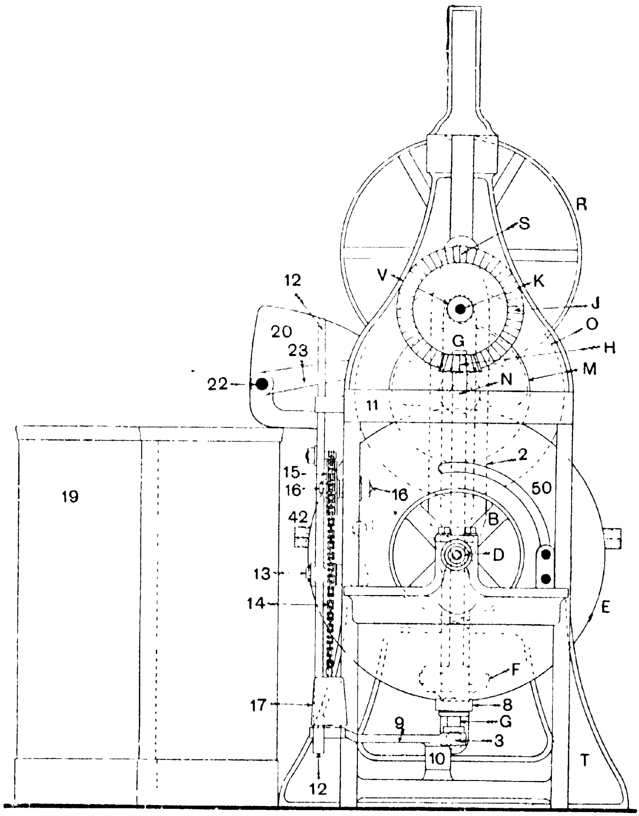


FIG. 112.

diameter of the lap increases; this maintains, as already mentioned, a constant speed of the slivers.

When the length of 100 yds. has been wound on to the pin C, the roll or lap 21, Fig. 111, will be of the size indicated, and the

friction bowl F will be near to the centre of the friction plate E, as illustrated in this figure. In other words, since it is essential

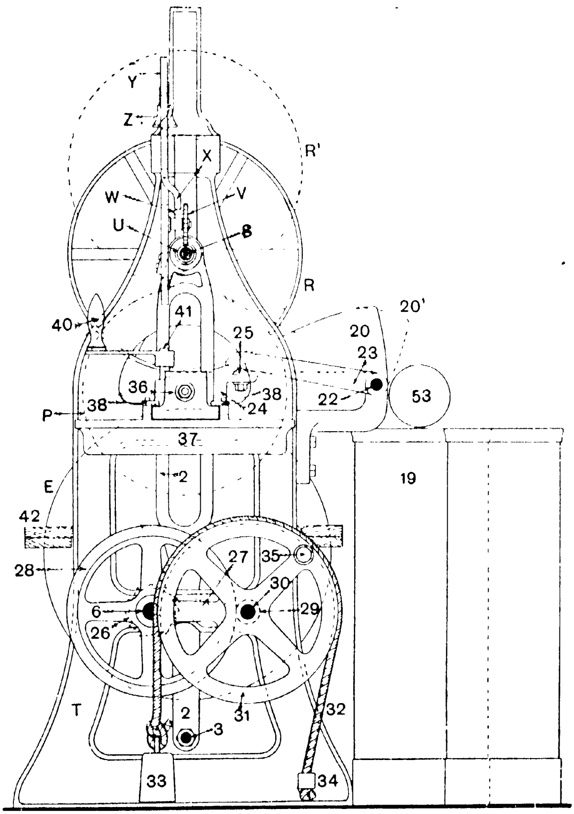


FIG 113.

that the surface speed of the slivers should be constant so as to disarrange them as little as possible, it follows that the speed of the pin C, with its layers, must decrease gradually, and this is accomplished in the manner described by causing the leather-faced friction

bowl F to be driven at a gradually decreasing speed in virtue of its coming into contact with smaller and smaller diameters of the friction plate E, which itself revolves at a uniform speed throughout.

The pressing and measuring drum R is two yards in circumference, so that with a single-thread worm U it follows that the worm-wheel V must have 50 teeth in order that it may make one complete revolution for every 100 yds. of sliver. If a double-thread worm be used, a worm-wheel of 100 teeth would be necessary. As the worm-wheel V moves round, Figs. 110, 111, 113, and 114, the pin W approaches and ultimately comes into contact with the small spring X. The further rotation of the wheel V and the pin W causes the latter to push the spring X outwards, and also to carry the spring Y and the bell Z with it. Immediately the small pin W slips over the end of the small spring X, the main spring Y springs forward to its normal position, and the vibration thus imparted to the spring Y causes the bell Z to ring. The attendant then groups all the six slivers together quickly, and pulls the set-on handle 12 to the position indicated in Fig. 111.

The sliver guides 20 are fulcrumed on the same shaft 22, Figs. 112 and 113, as the lever 23, which rotates the latter. During the filling of the lap it is necessary that the guides 20 should deliver the six slivers to the nip between the lap and the pressing drum R. Projecting from the edge of one of the connecting arms 2 is a small bracket 24, Fig. 113, to which is secured an adjustable convex-shaped stud 25. As this bracket 24 rises in unison with the connecting arm 2, it follows that the rounded head of stud 25 will cause the lever 23 to rotate partially clockwise, and gradually to cause the sliver guides 20 to carry the slivers as desired until finally, when the lap is finished, the guides occupy the position marked 20^1 in Fig. 113, and that in Fig. 106. In the latter figure, the lever 23 is shown clearly in his highest position, and so is the drum R and the guides 20.

As the pressing drum R is being raised gradually from the position indicated in Figs. 107 and 113 to that shown in Figs. 106 and 111, and the position marked R^1 in Fig. 113, it is evident that the racks 4 on the connecting arms 2 will rotate the pinions 5 and the shaft 6. A ratchet-wheel 26, Figs. 110 and 113, is fixed to the shaft 6, and the usual retaining pawl 27 is provided; the pawl is supported by a

stud fixed in one of the frames T. The pawl 27 and the ratchet-wheel 26 thus serve to keep the pressing drum R in its raised position until the lap has been removed.

On the end of the shaft 6, Fig. 113, is a spur-wheel 28, which is

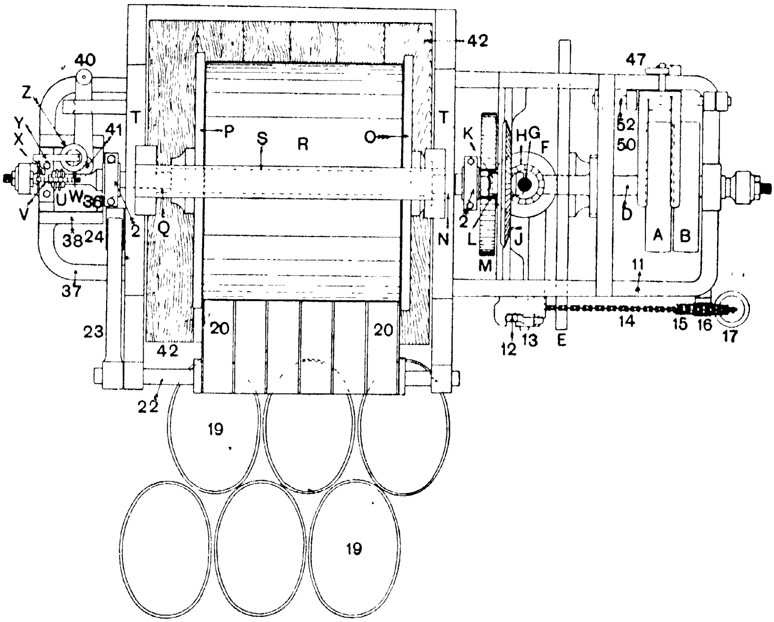


FIG. 114.

in gear with a spur pinion 29 on a stud 30; connected with the pinion 29 is a grooved hand-wheel 31—naturally on the same stud 30. Occasionally a brake rope 32 (see also Figs. 106 and 107), or other suitable friction band, is passed round the grooved hand-wheel 31, and carries a weight 33. In Fig. 111 the rope is supposed to be cut off, and only the sections of it appear in the groove; but in Figs. 106, 107, 110, and 113, the rope is in position. Figs. 106, 111, and 113 show the bracket 34 to which the end of the rope is attached.

bowl F to be driven at a gradually decreasing speed in virtue of its coming into contact with smaller and smaller diameters of the friction plate E, which itself revolves at a uniform speed throughout.

The pressing and measuring drum R is two yards in circumference, so that with a single-thread worm U it follows that the worm-wheel V must have 50 teeth in order that it may make one complete revolution for every 100 yds. of sliver. If a double-thread worm be used, a worm-wheel of 100 teeth would be necessary. As the worm-wheel V moves round, Figs. 110, 111, 113, and 114, the pin W approaches and ultimately comes into contact with the small spring X. The further rotation of the wheel V and the pin W causes the latter to push the spring X outwards, and also to carry the spring Y and the bell Z with it. Immediately the small pin W slips over the end of the small spring X, the main spring Y springs forward to its normal position, and the vibration thus imparted to the spring Y causes the bell Z to ring. The attendant then groups all the six slivers together quickly, and pulls the set-on handle 12 to the position indicated in Fig. 111.

The sliver guides 20 are fulcrumed on the same shaft 22, Figs. 112 and 113, as the lever 23, which rotates the latter. During the filling of the lap it is necessary that the guides 20 should deliver the six slivers to the nip between the lap and the pressing drum R. Projecting from the edge of one of the connecting arms 2 is a small bracket 24, Fig. 113, to which is secured an adjustable convex-shaped stud 25. As this bracket 24 rises in unison with the connecting arm 2, it follows that the rounded head of stud 25 will cause the lever 23 to rotate partially clockwise, and gradually to cause the sliver guides 20 to carry the slivers as desired until finally, when the lap is finished, the guides occupy the position marked 20^1 in Fig. 113, and that in Fig. 106. In the latter figure, the lever 23 is shown clearly in his highest position, and so is the drum R and the guides 20.

As the pressing drum R is being raised gradually from the position indicated in Figs. 107 and 113 to that shown in Figs. 106 and 111, and the position marked R^1 in Fig. 113, it is evident that the racks 4 on the connecting arms 2 will rotate the pinions 5 and the shaft 6. A ratchet-wheel 26, Figs. 110 and 113, is fixed to the shaft 6, and the usual retaining pawl 27 is provided; the pawl is supported by a

type in the background and on the right in Fig. 106—and sets made up to a given weight, say, from 160 lb. to 230 lb., depending upon the class. If the laps are not the correct weight, the weigher selects the proper number which will aggregate the exact weight required; but if, through any cause, all laps happen to be too light or too heavy, the weigher signals to the attendant at the breaker card to make the necessary change in the feeding of the fibre. A common practice is for the weigher to raise his hand if the balls are required to be heavier, and to lower his hand if they should be lighter.

The belt for the pulleys A and B, Figs. 107 and 110, is moved by means of the handle 47, fulcrumed at 48. A small pin 49 projecting from the back of the belt fork 50 enters a hole in the handle 47. The bottom of the belt fork is secured to the sliding rod 51, while the boss near the lower end of the forks is capable of sliding on the rod 52. Hence, when the handle 47 is moved to the left, Fig. 110, the belt fork 50 carries the belt on to the loose pulley B. As already mentioned, however, this handle is scarcely ever moved by the attendant, but it is useful if, for any particular purpose, all parts of the machine are required to be brought to a standstill. In many machines the slivers pass direct from the sliver cans to the guides, as already indicated, whereas in others, notably that illustrated in Fig. 106, and also in Fig. 113, a rotating tin cylinder 53 is provided.

While the balling or lap system possesses certain advantages, it obviously introduces another machine into the system and a corresponding extra operation. In general, the chief disadvantage of the lap system is the possibility—indeed, the probability—of broken slivers in the operation. When the slivers break, or when one sliver only breaks, which is the more common, it is evident that the group of slivers at that point and for the length in which this sliver is missing will be considerably reduced in thickness, being equal to five-sixths of the normal. Hence, there are more chances of "smaller ends" at the finisher card with this system than there are when the slivers come direct from the sliver cans to the feed sheet. Various safeguards have been introduced from time to time in connection with the feeding of finisher cards, and these are illustrated in Figs. 122 to 125, 127 to 129 and described on pp. 218 to 222.

CHAPTER XIII

FINISHER CARDS. THE "LOW" FINISHER CARD WITH CALCULATIONS

OWING to the nature of the first carding operation, and the original condition of the pieces of jute, the sliver delivered at the front of the breaker card must, in spite of efficient and regular feeding, be rather irregular in thickness; while the individual fibres of which the sliver is composed must also be somewhat irregular both in thickness and in length. This imperfection on the part of the sliver necessitates the continuation of the carding operation on a finer scale and with finer adjustments. These subsequent carding operations are invariably conducted in what is known as a "finisher card," and all such cards are provided with more pairs of rollers and with finer covering or clothing than what are required or used in breaker cards, and is, in general, similar to those exhibited in Nos. 13 to 26, Fig. 78.

The most general type of finisher card is termed a full-circular four-pair machine. Opinions vary as to which type of finisher card is the most efficient for the continuation and completion of the carding process of the slivers from the breaker card, and although the above-mentioned four-pair card is used more extensively than any other type, other kinds are also used for the production of standard hessian yarns, as well as for yarns of other sizes and other qualities of material. Thus, there are half-circular cards with three pairs of rollers, and half-circular cards with four pairs of rollers, and it is not uncommon to find cards with five pairs or even six pairs of rollers. In addition, variations obtain in the size of the rollers, such variations depending sometimes on the number of pairs employed. Details of a few of these machines will be supplied near the end of the description and illustration of this important branch of the preparation of jute, but in the meantime, and since the four-pair type is

most widely adopted, we shall describe and illustrate this particular kind of machine.

As stated on page 114, the object of carding is to produce fibres of a uniform diameter, and also of uniform length, and the operation which is performed on the finisher card is essentially the same as that which obtains in the breaker card, but takes place at more points and with more pairs of rollers, and it helps considerably to achieve the above ideal object. The process is made more effective by what

FIG. 115.

is known as "doubling the slivers." The definition would appear to indicate that two slivers were joined in some way, and this might have been the case originally. The term "doubling," however, is used in a more extended manner, and, in general, means the combination at the feed of any number of slivers for the purpose of obtaining a more uniform sheet of material—and hence a more uniform sliver—than is possible by the method of making slivers in the breaker card, and for other purposes which will be discussed at a later stage of this work.

The four-pair full-circular finisher card which we purpose

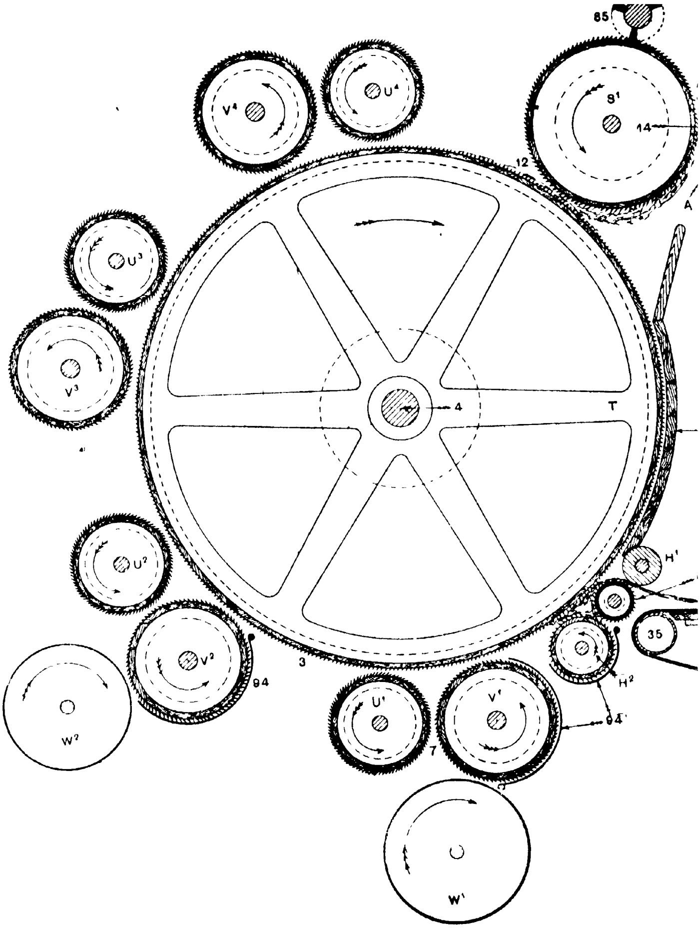
illustrating is that made by Messrs. James F. Low & Co., Ltd., Monifieth, and illustrated in Figs. 115 to 121 inclusive. The chief rollers and gear-wheels are lettered and numbered consistently in all the figures, and in order to preserve uniformity as far as possible for the sake of calculations, the various parts in this machine are identified by the same letters and numbers as the corresponding parts in the breaker cards which have already appeared.

Both the feed and delivery are at the front, as illustrated in the general view in Fig. 115 and in the sectional elevation in Fig. 116. The former view shows that there are 12 different slivers coming from 12 different sliver cans, and then passing between the numerous sliver guides to the feed sheet; a single sliver can is shown to the left of the group of 12, and the finished sliver is shown emerging from the rollers and dropping into this solitary can, which is, naturally, immediately below the delivery rollers.

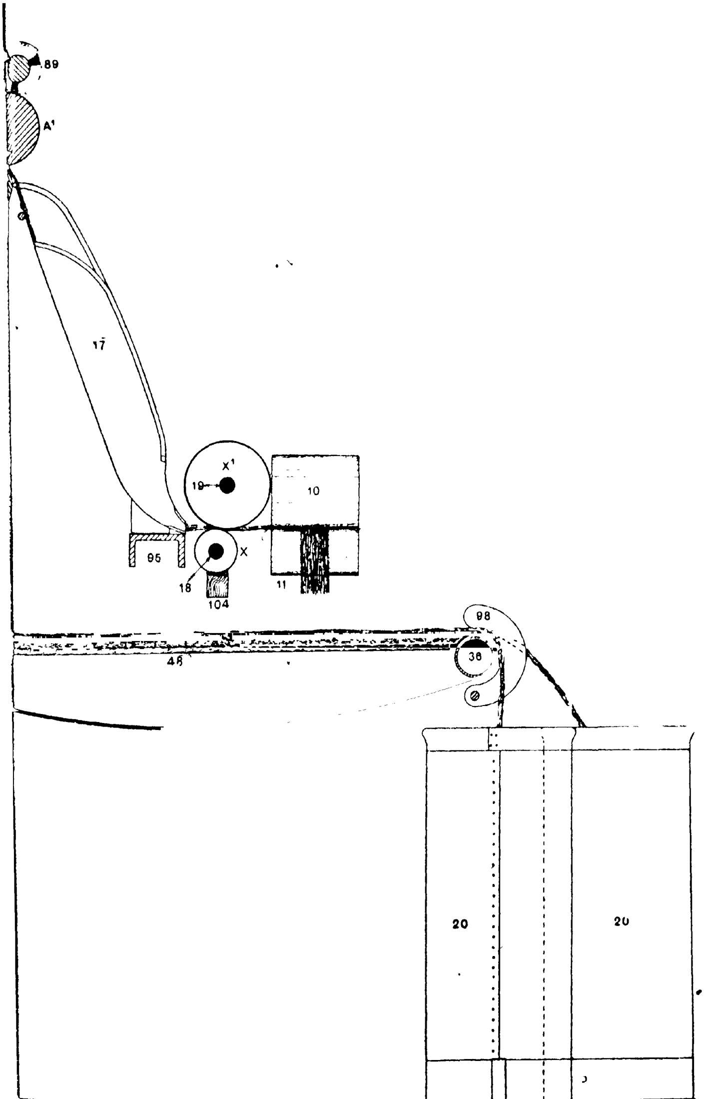
In Fig. 116 two sliver cans 20 only are, of course, seen—the end one in each row of six—and the two slivers from these cans indicate the method in which all the twelve slivers are led, or, rather, drawn, over the feed sheet 1 and to the feed roller H, and between it and the upper roller H^1; finally, they pass between the cylinder and the feed stripper H^2, at which point the illustration of the sliver finishes in the drawing so as not to obliterate the remaining parts. It will be understood, however, that the fibres follow a path around each pair of rollers very similar to that illustrated in Fig. 57, page 94. The type of feeding illustrated in Fig. 116 will be referred to in detail when the various types of feeding mechanism are considered.

The twelve slivers, after leaving the feed rollers H, H^1, and H^2, are, therefore, broken, carded, or combed at four different places by the four workers U^1, U^2, U^3, and U^4, and the four strippers V^1, V^2, V^3, and V^4. Two tin cylinders W^1 and W^2 only are used.

When the broken and carded fibres arrive at the doffing rollers S^1 they follow the path indicated from that point to the conductor 17; they then follow a path which will be indicated in the plan view, and ultimately are delivered as shown by the rollers 10 and 11. Here again the sliver is broken in the drawing. The difference between the doffing arrangements in Fig. 72 (page 124) and Fig. 116 should be noticed. In the latter figure the fibres pass amongst the pins on the underside of the doffing roller S^1, while in Fig. 72 the



85
V⁴
U⁴
S¹
14
12
A
U³
V³
4
T
U²
H¹
35
V²
94
3
H²
U¹
V¹
94
7
W²
W¹



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fibres, although not shown, pass amongst the pins on the upper side of the doffing roller S^1, and precisely as indicated in the above-mentioned Fig. 57.

The gear side of the machine is partially illustrated in Fig 115, and completely exhibited in Fig 117, in which view the gear cage or guard is removed in order that all parts may appear to the best advantage. The side sliver can 20^1 and the side delivery rollers

FIG 117

10 and 11 are prominent in this figure, and equally prominent in the line drawing of the gear side.

From Fig. 117 it will be seen that the main cylinder shaft 4 is reduced near this side for the cylinder pinion J. This pinion J, through intermediate wheels 23, 40, and 41, drives the wheel B on the shaft 15 of the drawing roller A. Between wheel B and the frame 29, and on the same shaft 15, is a pinion 51 which drives the wheel 52 on the shaft 16 of the pressing roller A^1

The drive to the feed roller wheel G may be considered as proceeding either from the cylinder pinion J or from the drawing roller

wheel B. The wheels involved in the draft gearing, say, from the drawing roller 15, will be—

> The drawing roller wheel B;
> The compound wheels C and D, and
> The compound wheels E and F;

the change pinion in this train of wheels is F.

The pulley side of the machine is illustrated in Fig. 119. No photographic reproduction has been prepared for this side, but if Fig. 115 is consulted, a very similar drive will be seen illustrated on the right, such drive being obviously connected with the next machine to that to which the photograph refers.

On the end of the drawing roller shaft 15, Fig. 119, is a pinion P, which drives the compound wheels Q and R. The latter drives the doffing roller wheel S—keyed on shaft 13 of the doffing roller S′—through the intermediate wheel 58.

The motion to the four workers U^1 to U^4, Fig. 118, from the doffing roller shaft 13, is by means of an intermediate wheel 61, and the wheels M^4, M^3, M^2, and M^1, together with the three intermediate wheels, all of which are numbered 53. Each wheel is provided with its stud, stud plate, and means of adjustment as shown.

Returning now to Fig. 119, and considering also the plan view in Fig. 120, it will be seen that the belt 21 in the former view passes round the loose pulley Y′. Both this and the fast pulley Y are shown in Fig. 120, but the belt is omitted in this view. The belt is controlled as usual by the belt-fork 117 attached to the sliding bracket 116. The hand-wheel 120, pinion 119, and the rack bracket 115, enable the operative to transfer the belt-fork, and therefore the belt, towards the frame and until the belt runs on to the fast pulley Y. Then, of course, the machine starts. Between the fast pulley Y and the frame 29 is the stripper driving pulley N; the strippers V^1 to V^4, on shafts 8, are driven as usual from this pulley by means of the endless belt 73′, which passes, as shown, partially around the four stripper pulleys O^1, O^2, O^3, and O^4, while a tension pulley Z is also provided.

The upper boxing 94 opens as usual to permit insight to the various rollers. One part of the boxing is shown open in Fig. 117, but in the other views it is closed. A hook 99 at each end, Fig. 119, is fixed to the boxing as shown, and when the latter is raised to the

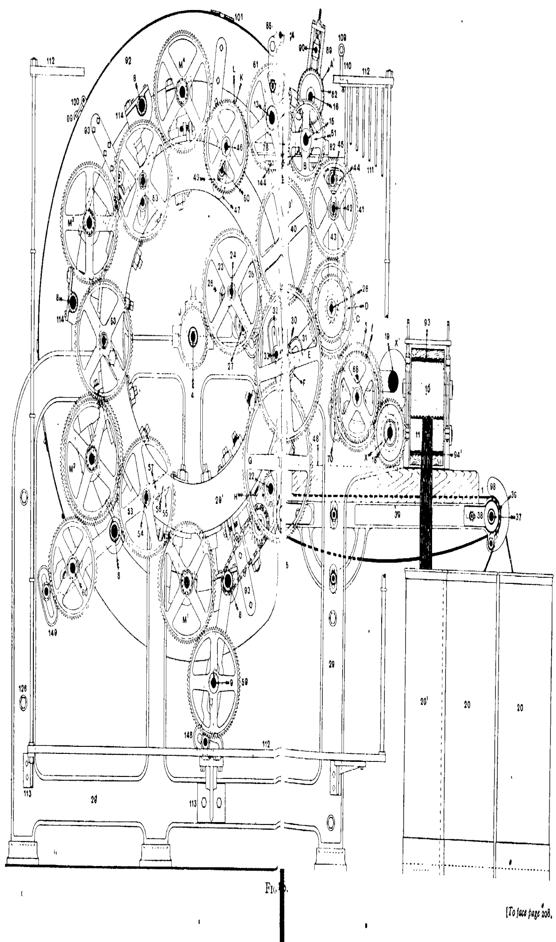

FIG. 5.

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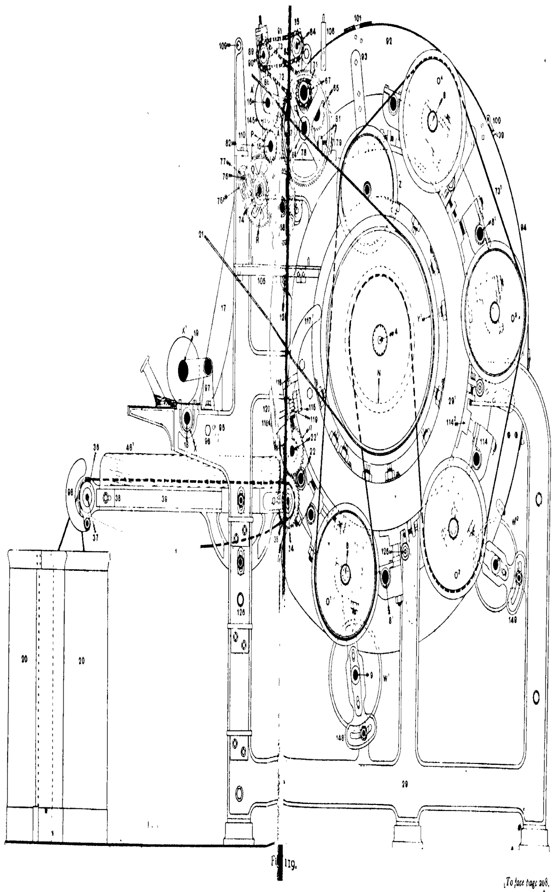

Fig. 119.

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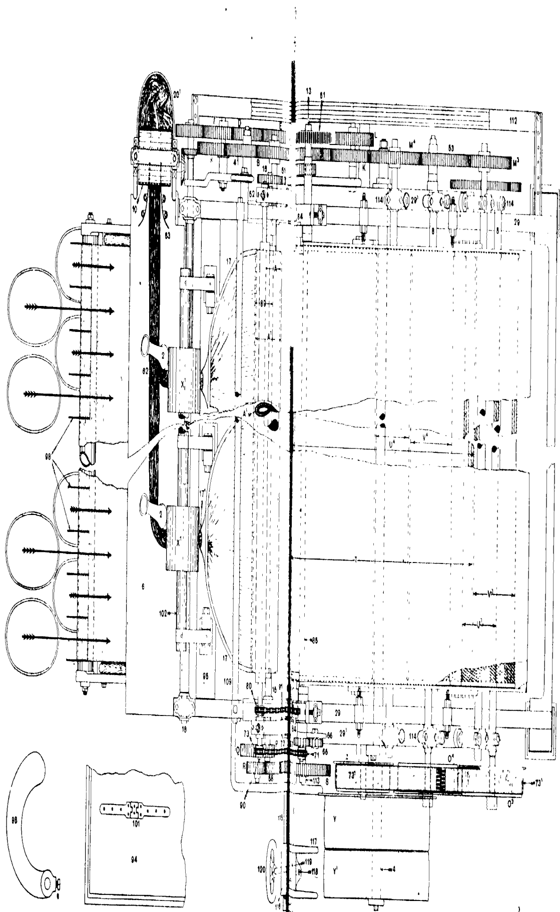

FIG. 12[illegible].

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position indicated in Fig. , the said hooks 99 are caught by the hanging loops or links 100, . the boxing is then held open The link takes hold somewhat as astrated in Fig. 118, although the boxing is shown closed; the c positions of the parts 99 and 100 when the boxing is closed are own in Fig. 120 A part of the upper boxing is shown detached his figure, with the necessary hinges 101.

The feed sheet 1, Fig. 119, is driven from the shaft 22′ by wheel *a* and wheel *b* on the shaft 34 of the feed-sheet roller 35.

As already indicated, when the sheet of fibres emerges from the drawing rollers, it immediately enters th conductor 17. In some cases a single conductor is used, and iden ical with that shown on the breaker card, in others, again, the sheet of fibres is made to pass down two conductors, side by side, the sheet being split in two as shown clearly in Fig 115, as well as in Fig 120. When two slivers are formed in this way, each sheet is contracted in the usual way, and the two slivers are delivered from the two mouths 17′ of the conductors to the two delivery rollers X and X′. Then the two slivers emerge from the rollers, and are immediately caused to move at right angles under the action of the side del very rollers 10 and 11, and the horns or studs 2 which project fr the upper surface of the sliver plate 6. The two slivers combine at 62, and pass jointly, as mentioned, to the side delivery rollers 10 and 11, to be finally deposited into a sliver can 20′ as exemplified in all the figures except 119 and 121. The latter figure is an enlarged view of one of the worker studs, and is introduced chiefly to show the method of adjusting the said workers in two d ections.

There are two clearing brush 85 and 89, Figs. 118 to 120. The brush 85 cleans the doffer while the brush 89 cleans the leather-f ed pressing roller A′ oth brushes are driven as follows: Betwee . the doffing roller S, Fig. 119, and the block 78, is a wheel 64 which drives th l 65 on a bracket 66, Fig. 120; wheel 65, Fig. 119, then driv wheel 67 which is compounded with a sprocket-wheel, 71. A chain 72 connects and drives a similar sprocket-wheel 73 on the shaft 90 of the brush 89. A further chain 91 is driven by a . . rd sprocket-wheel 80, Fig. 120, on the shaft 89, and conveys motion to a fourth sprocket-wheel 83 (see also Fig. 119) on shaft 84 of the brush 85.

It will be understood that it is sometimes considered necessary that all the slivers from the cans 20, Fig. 120, should be equally divided over the feed sheet 1. This sheet is shown stippled in this view, and the eight heavy arrows—the central part of the machine being omitted for the purpose of exposing some of the internal parts —indicate the direction followed by the 12 slivers. To obtain this equal distribution, conductors or division plates 98 are fixed

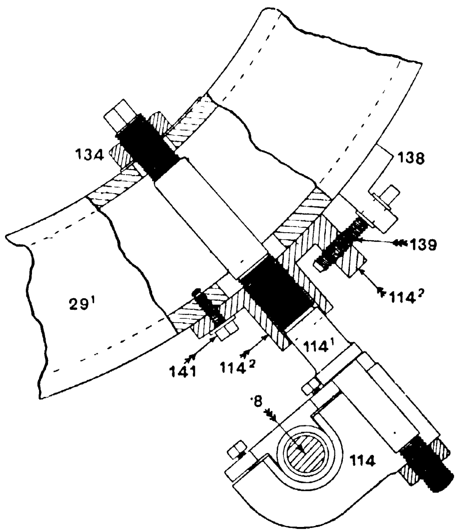


FIG. 121.

to the bracket 38 of the feed roller (see Figs. 118, 119, and the enlarged detached view in Fig. 120).

All the gearing in the upper part of the pulley side, Fig. 119, is, of course, fenced when the machine is in operation. This fence or guard is not shown in the figure, but when in position it rests upon the rails 105 and 106, the projecting pins from these rails entering into holes which are drilled in the guard.

A typical kind of covering or card clothing for the finisher card illustrated in Figs. 115 to 120, is as follows :—

Name of Roller	Dia. in In. Under Cover	Thickness of Stave	Pitch of Pins	Wire Gauge No. of Pins	Total Length of Pins	Angle of Pins.
Cylinder	48	$\frac{9}{16}$ in.	$\frac{3}{8}$ by $\frac{3}{8}$	15	$\frac{7}{8}$ in.	70°
Feed roller	3	*$\frac{1}{4}$,,	$\frac{3}{8}$,, $\frac{3}{8}$	14	$\frac{5}{8}$,,	60°
Feed stripper . . .	5	$\frac{7}{16}$,,	$\frac{3}{8}$,, $\frac{3}{8}$	15	1 ,,	35°
1st and 2nd strippers .	10	$\frac{7}{16}$,,	$\frac{3}{8}$,, $\frac{3}{8}$	15	1 ,,	42°
3rd and 4th strippers .	10	$\frac{7}{16}$,,	$\frac{3}{8}$,, $\frac{5}{16}$	15	1 ,,	42°
1st and 2nd workers .	8	$\frac{9}{16}$,,	$\frac{3}{8}$,, $\frac{5}{16}$	14	$1\frac{1}{2}$,,	34°
3rd and 4th workers .	8	$\frac{9}{16}$,,	$\frac{3}{8}$,, $\frac{1}{4}$	14	$1\frac{1}{4}$,,	34°
Doffer	15	$\frac{1}{2}$,,	$\frac{5}{16}$,, $\frac{5}{16}$	15	$1\frac{1}{8}$,,	40°

* Brass.

Each stave is one-third the working width of the roller, so that there are three staves in each row in all the rollers

The above covering is rather finer than that used on some other finisher cards which are used in the preparation of slivers intended for the same size of yarns. Cards clothed according to the particulars in the above table have, however, been found in practice to give excellent results, and a little consideration should prove that such a scheme of card clothing is calculated to provide efficient means for treating fibre which requires rather more carding than is considered sufficient for many grades of material.

The gauging or setting of the various rollers on a finisher card clothed as exemplified will naturally depend somewhat on the work in hand, and upon the character of the finished product. For medium classes of jute fibre, and when the machine is first started, the following particulars of gauging would do very well :—

Feed roller to cylinder	No. 14 gauge.
,, ,, plain roller . . .	,, 16 ,,
Feed stripper to feed roller	,, 14 ,,
,, ,, cylinder . . .	,, 14 ,,
First worker to cylinder . .	,, 11 ,,
Second ,, ,, ...	,, 12 ,,
Third ,, ,, ...	,, 13 ,,
Fourth ,, ,, ...	,, 14 ,,
First stripper to cylinder	,, 14 ,,
Second ,, ,, ...	,, 14 ,,
Third ,, ,, ...	,, 14 ,,
Fourth ,, ,, ...	,, 15 ,,
First / Second / Third strippers to first / second / third workers	,, 14 ,,
Fourth stripper to fourth worker	,, 15 ,,
Doffer to cylinder	,, 15 ,,
Drawing roller to doffer	$1\frac{1}{2}$ in.
Leather pressing roller to doffer	No. 12 gauge.

If more or less carding were required, the alteration of the gauging could be made in the usual way by decreasing or increasing the gap between the various rollers—that is, by adopting closer or wider gauging—or the speed of the workers could be reduced to obtain more cutting, while an increase in the speed of the latter rollers could be made for less cutting.

We might with advantage draw the reader's attention to the difference in the gauging for the above card and for that of the breaker card already fully described, and also to the difference in the relative positions of the drawing rollers and the top pressing rollers with regard to the doffing rollers in these two distinct types of cards.

In the sectional view of the breaker card illustrated in Fig. 72, page 124, and in the sectional view of the doffer and part of the cylinder in Fig. 86, page 163, no fibre is shown on the pins. The arrangement of the doffing roller, drawing roller, and top pressing roller in these figures is practically identical with the corresponding parts in the root comber, illustrated in Fig. 57, page 94, from which it will be seen that the sheet of fibres passes over the top of the doffer and then into the nip of the drawing and top pressing rollers. On the other hand, the corresponding sheet of fibres in the sectional view of the finisher card illustrated in Fig. 116, page 206, passes under the doffing roller, and then up to the nip of the drawing and top pressing rollers.

In the description of the carding and cutting action in breaker and finisher cards it is usual to attribute the whole of the work to the joint action of the feed roller and cylinder, and the various workers and cylinder. The relative positions of the pins of the doffer and those of the cylinder are very similar to the relative positions of the pins of the workers and the cylinder, and hence it is quite safe to assume that a certain amount of combing and splitting takes place between the pins of the doffer and those of the cylinder. The amount of research on this particular subject is perhaps not sufficiently extensive to enable one to say what degree of combing and splitting takes place between the doffer and the cylinder, nor what takes place between the workers and the strippers. But that some work of this nature is performed at both places will, we think, be admitted by most who study the general action of carding in the various machines which have been illustrated up to this point in this work, and,

.t the same time, a more or less relatively correct estimate can be nade of the work which is conducted at the various points.

Towards the end of this section of the work we shall discuss the arding and combing actions under various conditions of clothing, ind at the same time shall take into consideration the joint effect f the above with the alteration of the speeds of the rollers for specific urposes In the meantime, we purpose introducing the essential alculations in connection with the finisher card.

The speed of the cylinder in finisher cards varies in general rom 160 to 180 revs. per min., although the latter speed is sometimes xceeded. The actual speed which obtains in any case is slightly ower than that shown by the numerical calculation, the reduction eing due to the slip which takes place between the drum, pulley, nd driving belt. Since this degree of slip is a varying quantity, o hard-and-fast rule can be observed with regard to it.

With a speed of 200 revs of the shaft carrying a 27 in. drum, and 30 in. pulley on the card, we have -

$$(96) \qquad \frac{200 \times 27}{30} = 180 \text{ revs. of cylinder T};$$

hereas the actual number of revolutions may approximate to 175. ince it is essential, or, rather, desirable, that the speeds of all the ollers should be considered with relation to the actual speed of ie cylinder as found by a counter, we shall assume that with the bove particulars we generate an actual cylinder speed of 175 revs. er min. Consequently, if x represents the percentage of slip, we ave—

$$(97) \qquad 180 - \frac{x}{100} \times 180 = 175.$$

$$x = 2{\cdot}77 \text{ per cent. slip.}$$

s in the case of the breaker card, we have—

$$(98) \quad \text{Revs. of cylinder T} \times \frac{\text{J}}{\text{B}} = \text{revs. of drawing roller A};$$

id the speed of the drawing roller should be sufficient to deliver y, 25 cwt. of sliver per day of 10 hours, such sliver to weigh 12 lb. r 100 yds.

Assuming that each sliver from the breaker card weighs 15 lb.

per 100 yds., and that 12 of these slivers enter the finisher card as depicted in Fig. 115, and emerge from the delivery rollers as one sliver weighing, as stated, 12 lb. per 100 yds., we should have—

$$(99) \quad \frac{15 \text{ lb. sliver} \times 12 \text{ slivers}}{\text{Finisher draft}} = 12 \text{ lb. per 100 yds.};$$

hence—

$$(100) \quad \text{Finisher draft} = \frac{15 \text{ lb.} \times 12 \text{ slivers}}{12 \text{ lb.}} = 15.$$

Since the identification letters are the same for both breaker and finisher cards, the draft gearing is as under:—

$$(101) \quad \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{H} = \text{draft};$$

hence, inserting the above-mentioned necessary draft of 15 in (100), and the values of the wheels except the unknown change pinion F in (101), it is clear that—

$$(102) \quad \frac{4}{60} \times \frac{72}{48} \times \frac{116}{F} \times \frac{118}{4} = 15 \text{ draft}.$$

$$(103) \quad \therefore \quad F = \frac{4 \times 72 \times 116 \times 118}{60 \times 48 \times 15 \times 4} = 22\cdot 8, \text{ say 23 teeth}.$$

Another way of finding the change pinion F is by ascertaining the constant number of the draft gearing—that is, the value of all the wheels except the change pinion F—and then dividing this constant number by the draft. Thus—

$$(104) \quad \frac{A}{B} \times \frac{C}{D} \times \frac{E}{1} \times \frac{G}{H} = \text{constant number};$$

$$(105) \quad i.e., \quad \frac{4}{60} \times \frac{72}{48} \times \frac{116}{1} \times \frac{118}{4} = 342,$$

$$(106) \quad \text{and} \quad \frac{\text{Constant number}}{\text{Draft}} = \text{change pinion F}.$$

$$(107) \quad \therefore \quad \frac{342}{15} = F = 22\cdot 8, \text{ say 23 teeth as before}.$$

The production required

$$(108) \quad \begin{cases} = 25 \text{ cwt. per day.} \\ = (25 \times 112) \text{ lb. per day.} \\ = 2800 \text{ lb. per day.} \end{cases}$$

And, since every 100 yds. of the finisher sliver should weigh 12 lb., we have—

(109) $2800 \text{ lb.} \times \frac{100 \text{ yds.}}{12 \text{ lb.}}$ = number of yards per day;

and the above divided by 600 mins. per day gives—

(110) $\frac{2800 \times 100}{600 \times 12} = 38{\cdot}8$ yds. per min.;

or $38{\cdot}89 \times 36 = 1400$ in. per min.

(111) Now, $\frac{\text{Delivery in inches from A}}{\text{Circumference of A}}$ = the revs. per min. of A, the drawing roller;

hence—

(112) $\frac{1400 \text{ in.}}{4 \text{ in.} \times 3{\cdot}1416} = 111$ revs. of A;

and since—

(113) $\frac{\text{Revs. of A} \times \text{B}}{\text{Revs. of cylinder T}} = \text{J}$, the cylinder pinion,

it follows that—

(114) $\text{J} = \frac{111 \times 60}{175} = 38$ teeth.

The nearest cylinder change pinion J would probably be 40 teeth, therefore—

(115) $175 \times \frac{40}{60} = 116{\cdot}\dot{6}$ revs. of drawing roller A

From this speed of the drawing roller A we can at once find the speed of the doffer. Thus—

(116) $\text{Revs. of A} \times \frac{\text{P}}{\text{Q}} \times \frac{\text{R}}{\text{S}}$ = revs. of doffer;

(117) $116 \times \frac{22}{54} \times \frac{28}{88} = 15$ revs. of doffer S′;

while the speed of the worker is found as under:—

(118) $\text{Revs. of doffer S}' \times \frac{\text{S}''}{\text{K}} \times \frac{\text{L}}{\text{M}}$ = revs. of worker U

(Note: Wheel S″ is numbered 61 in Fig. 118);

(119) *i. e.*, $15 \times \frac{80}{64} \times \frac{68}{88} = 14{\cdot}49.$

The formula for the stripper is—

$$\text{(120)} \qquad \text{Revs. of cylinder T} \times \frac{N}{O}.$$

$$\text{(121)} \qquad \therefore \quad 175 \times \frac{16}{16} = 175 \text{ revs. of stripper V},$$

while the calculation for the feed is—

$$\text{(122)} \qquad \text{Revs. of T} \times \frac{J}{C} \times \frac{D}{E} \times \frac{F}{G} = \text{revs. of H},$$

$$\text{(123)} \qquad i.\ e.,\ 175 \times \frac{40}{72} \times \frac{48}{116} \times \frac{23}{118} = 7{\cdot}84 \text{ revs. of feed H}.$$

If now we collect all the essential data with regard to speeds from the above calculations, and convert the revs. per min. into the circumferential speeds of the various rollers, we can provide a useful table of speeds. The circumferential speeds in the undermentioned table are calculated from a point about midway between the lengths of the exposed pins, and this point is considered as the working diameter of the roller:—

Name of Roller.	Revolutions per Minute	Working Diameter, In.	Working Circumference, In.	Surface Speed per Minute, In.	Surface Speed per Minute, Ft.
Cylinder T . . .	175·0	49·5	155·51	27214·25	2267·25
Drawing roller A .	116·6	4·0	12·57	1465·66	122·14
Dotter S′ . . .	15·0	16·5	51·84	777·60	64·80
Worker U . . .	14·49	9·5	29·86	432·67	36·05
Stripper V . . .	175·0	11·25	35·34	6184·50	515·38
Feed roller H . .	7·84	4·0	12·57	98·55	8·21

Constant for draft = 342.
Draft used in above = 15.

The above particulars could, of course, be varied to suit special requirements. For instance, if it were desired to produce a finisher sliver weighing 10 lb. per 100 yds. from the same weight of breaker sliver as before—that is, 15 lb. per 100 yds.—the work could be done either by altering the number of slivers at the feed, or by altering the draft. In some cases it would be necessary to alter both.

It is a common practice in many mills to use 10 slivers at the feed instead of 12, as illustrated in Fig. 115, and if the former number

were used, with the same weight of 15 lb. per 100 yds. of breaker sliver, we should have the following :—

$$(124)\qquad \frac{15 \text{ lb. sliver} \times 10 \text{ slivers}}{\text{Finisher draft.}} = 10 \text{ lb. per } 100 \text{ yds.}$$

$$(125)\qquad \therefore \frac{15 \times 10}{10} = 15, \text{ the finisher draft as before.}$$

If, however, 12 slivers were used, as in formula (99), the calculation would be as under :—

$$(126)\qquad \frac{15 \text{ lb. sliver} \times 12 \text{ slivers}}{\text{Finisher draft}} = 10 \text{ lb. per } 100 \text{ yds.}$$

$$(127)\qquad \therefore \frac{15 \times 12}{10} = 18 \text{ of a draft.}$$

The general calculation is as follows :—

$$(128)\qquad \frac{\text{Weight of breaker sliver} \times \text{number of slivers at feed}}{\text{Weight of required finisher sliver}} = \text{the finisher draft.}$$

The above change to 10 lb. per 100 yds. for the finisher sliver, with a required production of 2800 lb. per day, would naturally alter the speed of the drawing roller A. Thus :—

$$(129)\qquad 2800 \text{ lb.} \times \frac{100 \text{ yds.}}{10 \text{ lb.}} = 28{,}000 \text{ yds. per day}$$

$$(130)\qquad \therefore \frac{28{,}000 \text{ yds.}}{600 \text{ mins. per day}} = 46\cdot6 \text{ yds. per min.},$$

or $46\cdot6 \times 36 = 1680$ in. per min.; and, since the circumference of the drawing roller A is 12·57 in. (see the above table of speeds), it follows that—

$$(131)\qquad \frac{1680 \text{ in.}}{12\cdot57 \text{ in.}} = 133\cdot7 \text{ revs. per min. of the drawing roller A.}$$

Hence to find the cylinder pinion J under these conditions we have—

$$(132)\qquad \frac{133\cdot7 \times 60}{175} = 46\text{-tooth pinion for J.}$$

The above alterations would also change the speed of the doffer, and that of the worker, and if these altered speeds were unsatisfactory, the necessary changes would have to be made to suit the degree of carding or cutting of the material under process. This

phase of the question is usually judged after the above-mentioned changes have been tried.

In nearly all cards there is provision made to minimise damage to the machinery in case of any obstruction in the working. This provision is known as a "pitch pin," and such pins are strong enough to effect the necessary drive when all is working satisfactorily; but in case of any serious obstruction, the pin is severed, in which case that particular part of the drive is arrested. Such pins are inserted at the most convenient point in the feed-gear in both breaker and finisher cards. The pitch pin for Fig. 118 is situated in the circular plate immediately behind wheel G, see Figs. 124 and 125.

Referring again to the card illustrated in Figs. 115 to 121, we reproduce on a larger scale a few illustrations of details. In con-

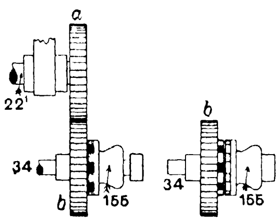


FIG. 122.

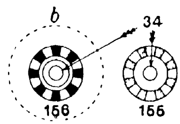


FIG. 123.

nection with the feed cloth roller, Fig. 122 shows parts which are provided for stopping this roller suddenly for any particular reason. The cloth roller shaft-wheel *b* runs loosely on the shaft 34, and is driven from the feed roller shaft 22^1 by the wheel *a*. A prong clutch 155 on the shaft 34 has corresponding parts 156 on the side of the wheel *b*. The clutch and shaft are provided with the usual feather and key-seat, by means of which the clutch may be slid on the shaft 34 and driven by the wheel *b*. The two views in Fig. 122 show the two halves of the clutch engaged for driving and disengaged respectively, while the two views in Fig. 123 illustrate the prongs and recesses in the two halves of the clutch. In all the views the driving prongs are shown in black, whereas the driven prongs are stippled.

As already stated, a safety arrangement is invariably applied to the feed gearing to sever the connection between the feed roller and a portion of the gearing in case any obstruction is accidentally

introduced at the feed sheet and roller. This simple and effective provision is illustrated in Fig. 124, and receives the technical name of "pitch pin" or "slip pin." The pin 157, shown in solid black, passes through a plate or disc 158 on the arm of the wheel G, which is loose on the shaft 22^1, and also through a corresponding plate 159 which is fixed to the shaft.

The pin 157 should be of sufficient strength only to drive the roller under normal conditions of feeding. Any abnormal condition, such as the introduction of too much material, or of some foreign substance at the feed, should cause the pin 157 to shear and thus prevent the roller from rotating. In Fig. 124 part of the wheel is

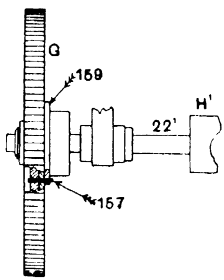


FIG. 124.

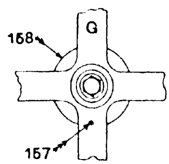


FIG. 125.

cut away in order to show the pin in the arm of the wheel and in the two plates. Fig. 125 is a front elevation of the arms of the wheel with the plate 158 behind, and the round black dot 157 shows the position of the pin in one of the arms of the wheel.

The construction of the leather-covered pressing roller A^1 is illustrated in the four views in Fig. 126. A hollow cast-iron roller with built-up ends forms the base of the roller as shown in the upper figure. The preliminary covering of the roller is also shown in this figure, and consists of a layer of wool plaiding wound round as indicated, and the edges sewn as demonstrated in the lower figure. The second layer of wool plaiding is shown in the middle view, and is wound on, as clearly indicated, in the reverse direction to the first. A third layer of wool plaiding, wound in the same direction as the first, is shown in the bottom figure, and part of each layer, with

phase of the question is usually judged after the above-mentioned changes have been tried.

In nearly all cards there is provision made to minimise damage to the machinery in case of any obstruction in the working. This provision is known as a "pitch pin," and such pins are strong enough to effect the necessary drive when all is working satisfactorily; but in case of any serious obstruction, the pin is severed, in which case that particular part of the drive is arrested. Such pins are inserted at the most convenient point in the feed-gear in both breaker and finisher cards. The pitch pin for Fig. 118 is situated in the circular plate immediately behind wheel G, see Figs. 124 and 125.

Referring again to the card illustrated in Figs. 115 to 121, we reproduce on a larger scale a few illustrations of details. In con-

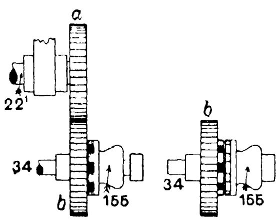


FIG. 122.

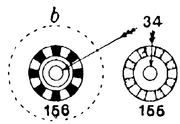


FIG. 123.

nection with the feed cloth roller, Fig. 122 shows parts which are provided for stopping this roller suddenly for any particular reason. The cloth roller shaft-wheel *b* runs loosely on the shaft 34, and is driven from the feed roller shaft 22¹ by the wheel *a*. A prong clutch 155 on the shaft 34 has corresponding parts 156 on the side of the wheel *b*. The clutch and shaft are provided with the usual feather and key-seat, by means of which the clutch may be slid on the shaft 34 and driven by the wheel *b*. The two views in Fig. 122 show the two halves of the clutch engaged for driving and disengaged respectively, while the two views in Fig. 123 illustrate the prongs and recesses in the two halves of the clutch. In all the views the driving prongs are shown in black, whereas the driven prongs are stippled.

As already stated, a safety arrangement is invariably applied to the feed gearing to sever the connection between the feed roller and a portion of the gearing in case any obstruction is accidentally

Figs. 128 and 129. The sliding bracket 116 appears in all, but the

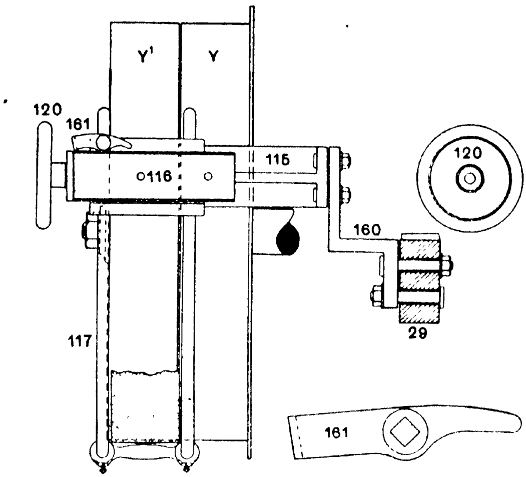


FIG 127.

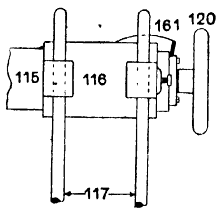


FIG. 128.

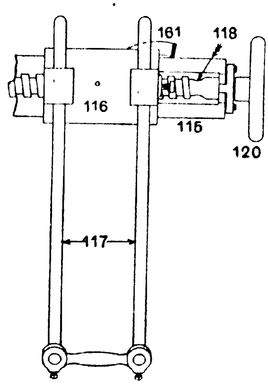
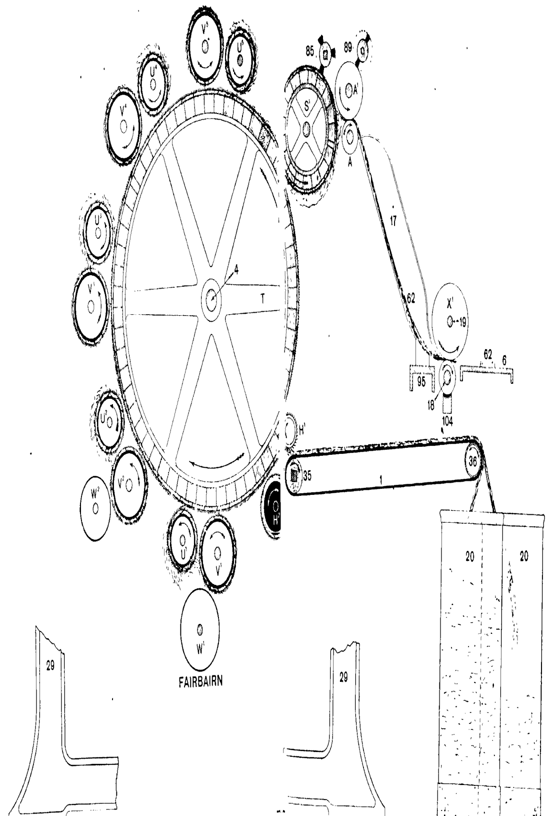


FIG. 129.

square-threaded screw on the shaft 118 for moving the bracket 116 is shown only in Fig. 129. A stationary bracket 115, fixed by means

of the ⅃-shaped bracket 160 to the frame 29 of the card, carries the sliding bracket 116 to which is attached the fork 117, as indicated in Figs. 128 and 129. The sliding bracket is moved by the hand-wheel 120, shown in all four figures, and the above-mentioned square-threaded screw in Fig. 129. A safety catch 161, shown detached on a larger scale in Fig. 127, is hinged on the sliding bracket 116 as shown in the latter figure. When the card is stopped with the belt on the loose pulley Y^1, as shown in Figs. 127 and 128, the bent end of the catch 161 lies over the end of the fixed bracket 115, and therefore prevents the automatic movement of the belt and belt fork. Before the card can be started, it is necessary for the attendant to raise the catch 161 clear of the end of the fixed bracket 115. As the bracket and fork are moved along when desired, the catch 161 slides on the upper surface of the fixed bracket as indicated in Fig. 129.



FIG

[To face page 223].

CHAPTER XIV

FIVE-PAIR FINISHER CARD AND COMPARISON OF FINISHER CARDS

FOR the production of the finest classes of yarns, and for which the ordinary 4-pair card is not considered adequately adapted, it is usual to construct a card capable of accommodating more pairs of rollers. In Fig 130 we illustrate a machine which has been successfully introduced into some jute mills for such work. The machine contains, as shown, five pairs of rollers with complete roller feed. In this illustration the path of the fibre through the whole of the machine is demonstrated. Thus, two sliver cans 20, one from each of the two rows, are shown with the slivers passing on to the feed cloth 1, from which they are carried between the pins of the two rollers, H and H^1, which constitute what is known as a "porcupine feed." As is usual with this form of feeding, a feed stripper H^2 is introduced, the reason for which, it will be seen, is that the fibre is carried partially round by the lower feed roller H in which the pins are set, so that part only of the fibre is removed by the pins of the cylinder T at this point. The remainder of the fibre is carried partially round by the roller H, as indicated, and is then removed from the pins of this roller by the pins of the feed stripper H^2.

The fibre thus passes to the pins of the cylinder, and thence in succession to the action of the five pairs of rollers, U^1, V^1, etc., as already described. The removal of the carded fibre from the pins of the cylinder at and by the pins of the doffer S^1 on the underside of the latter is also clearly shown. From this point the fibre enters the nip of the drawing roller A and the leather pressing roller A^1, then passes down the conductor 17, in which it is contracted as usual and delivered from the mouth to the delivery rollers X and X^1, where the fibre is broken off in the drawing. It will be understood, however, that the sliver passes round the horns or upright studs 2 on the sliver plate 6 exactly as demonstrated in Fig. 120, and then to the side delivery rollers 10 and 11, also shown in the latter figure.

There are three distinct and widely applied methods of feeding or conveying the slivers into the finisher card. One of these, the porcupine feed, has just been illustrated in Fig. 130, and is most suitable for feeding the cards when the load is light. In such a method it is evident that the pins of the two rollers could be set to intersect if desired, while the plain roller feed, shown in Fig. 131, offers no such choice. This arrangement, however, illustrates the large feed roller H which is being approved by many users. Fig. 132 illustrates the usual "shell feed" where the feed roller is covered with lags or staves with the usual complement of pins.

In connection with such a large and important subject as card

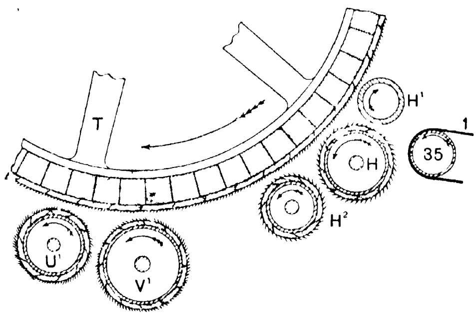


FIG. 131.

construction, it is clear that there will be a great diversity of opinion as to the particular design of machine and the arrangement of the many parts for different types of work, and even for the same type of work. In order to be able to locate any or all of the main organs of the machines, and specially to show the particular kinds and sizes of gear-wheels used, we have selected a number of the most widely used machines, and have reproduced diagrammatic drawings of these in Figs. 133, 134, and 135 in a form which should facilitate the selection of the various sets of gearing for connecting the different parts necessary for the proper regulation of the speeds.

These illustrations in Figs. 133 to 135 are supplemented by two tables, one for the half-circular finisher cards, and the other for the full-circular finisher cards; these two tables give the sizes of

all the rollers, and the number of teeth in the wheels, so that the calculations for any of the machines illustrated may be made by reference to the letters and numbers which are common to all, and to the types of calculations which have been fully demonstrated. For the sake of variety only, extremes of change pinions have been inserted in many of the diagrammatic drawings, but the full range of each set of changes will be found in the tables.

The inset in Fig. 133 illustrates the doffer gearing in the two

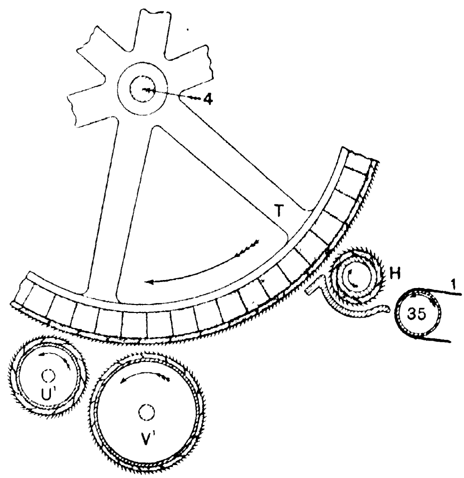


FIG. 132.

full-circular cards. The top inset in Fig 134 is the doffer gear for the two top cards, while the bottom inset is the doffer gear for the two bottom cards. The inset on the left in Fig. 135 is the doffer gearing for the Fraser card, while that on the right is the doffer gearing for the Combe-Barbour card.

The titles "Fairbairn," "Lawson," "Combe-Barbour," refer to the individual firms of the combine Messrs. Fairbairn Lawson Combe-Barbour Limited, Leeds and Belfast.

In the "Lawson" card illustrated in Fig. 135, the workers are driven direct from the doffer by the wheel marked L, which will be

HALF-CIRCULAR FINISHER CARDS

Distinguishing Letter or Number.	Fairbairn 3-pair.	Fairbairn 4 pair.	Lawson 3-pair.	Lawson 4 pair.	Low 3-pair.	Low 4-pair.	Fraser 3-pair.
A	4 in	4 in.	4 in.	4 in.	4 in.	4 in.	4 in
B	52	52	72	72	52	52	56
C	80	80	72	80	96	100	96
D	20 to 60	28	18	18	20 to 38	20 to 38	20 to 38
E	124	120	120	98	130	120	130
F	20	20 to 60	18 to 28	18 to 28	24	25	24
G	120	120	120	150	130	130	130*
H	10⅜ in.	10¼ in	9¼ in	12 in	11¾ in.	10¼ in	11½ in
J	20 to 60	20 to 60	36 to 60	36 to 60	45 to 60	56 to 70	48 to 60
K	75	120	156	136	96	84	96
K¹	90	--	--	--	106	112	108
L	30 to 48	20 to 60	28 to 36	28 to 36	34	28	30
L¹	36	--	-	—	38	28	33
M	136	136	162	150	88	80	88
N	14 in	14 in	16 in	16 in	14 in	14 in	14 in
O	18 in.	15 in	18 in	18 in	16 in.	16 in	18 in
P	24	32	24	24	24	24	24
Q	54	54	48	36	54	54	56
R	28	28	28	21	32	32	28
S	90	94	96	118	102	116	104
S¹	15¼ in	19½ in	15½ in	19½ in	17½ in	19½ in.	19¾ in.
T	49½ in	49½ in	49½ in	49½ in	49½ in	49½ in	49½ in
U	9¼ in	8¾ in	9 in	9 in	9¼ in	8½ in	9½ in
V	12½ in	10½ in	12½ in	12½ in	13½ in	10½ in	13½ in.
X	4¼ in	4⅜ in	4¼ in	4¼ in	5 in	5 in	5 in
Y and Y¹	24 or 30 in	24 or 30 in	24 or 30 in	24 or 30 in	24 or 30 in	24 or 30 in	24 or 30 in.
Z³	14 in	14 in	14 in	14 in	14 in	14 in	14 in
65	51 or 52	52	72	72	60	60	64

FULL-CIRCULAR FINISHER CARDS.

Distinguishing Letter or Number	Fairbairn 4-pair Roller Feed	Fairbairn 5-pair Roller Feed	Fairbairn 6-pair Roller Feed.	Combe-Barbour 4-pair Shell Feed	Lawson 4-pair Shell Feed.	Low 4 pair Roller Feed.	Low 4-pair Shell Feed.
A	4 in	4 in.	4 in.	4 in	4 in	4 in.	4 in.
B	75	75	72	68	72	60	60
C	104	104	120	100	65	72	72
D	32	28	50	32	20 to 30	48	48
E	104	96	120	112	96	116	104
F	20 to 60	20 to 60	24 to 60	20 to 40	20	20 to 40	16 to 34
G	96	96	120	90	96	118	156
H	*4 & 8 in	8 in.	*4 & 8 in	5½ in	4 in	4 in	5 in
J	20 to 60	40 to 80	24 to 72	32 to 68	36 to 64	30 to 60	30 to 60
K	72	72	66	72	—	72	72
K¹	—	-	84	—	--	—	—
L	64	64	28 to 36	50 to 100	See S¹¹	64	64
L¹	--	--	24	--	—	—	—
M	90	66	90	90	96	88	88
N	14 or 16 in	14 in.	20 in	16 in	16 in	16 in.	16 in
O	18 & 15 in	14 in.	15 in	20 & 18 in	24 in	16 in.	16 in.
P	24	24	24	24	18 to 23	24	24
Q	60	60	60	54	36	54	54
R	28	28	28	25	22	28	28
S	84	84	90	88	102	88	88
S¹	15¼ in.	14 or 18 in	16½ in.	15½ in	16½ in	16½ in.	16½ in.
S¹¹	84	84	—	80	50 to 58	80	80
T	49½ in	49½ in	61½ in	49½ in	49½ in	49½ in.	49½ in.
U	8½ in	7½ in	7½ in	8½ in.	9 in	9½ in.	9½ in
V¹ and V²	12½ in.	9½ in.	9½ in	12½ in	11½ in.	11½ in	11½ in.
V³ and V⁴	10½ in.	9½ in.	9½ in	11 in	11½ in.	11½ in	11½ in.
V⁵ and V⁶	—	9½ in	9½ in	—	—	—	—
X	4 in.	4 in	4 in	4 in	4½ in.	4½ in	4½ in.
Y and Y¹	24 or 30 in	24 or 30 in.	30 or 36 in.	24 or 30 in.	24 in.	24 or 30 in.	24 or 30 in.
Z³	14 in.	14 in	14 in	14 in	12 in.	14 in.	14 in.
65	22 or 23	23 or 52	22 or 23	66	72	48	60

* When the feed roller is increased to 8 in. diameter, the gear from the plain or pinned roller—whichever is used in these fine cards—is 24 and 49, in order to give the correct surface speed.

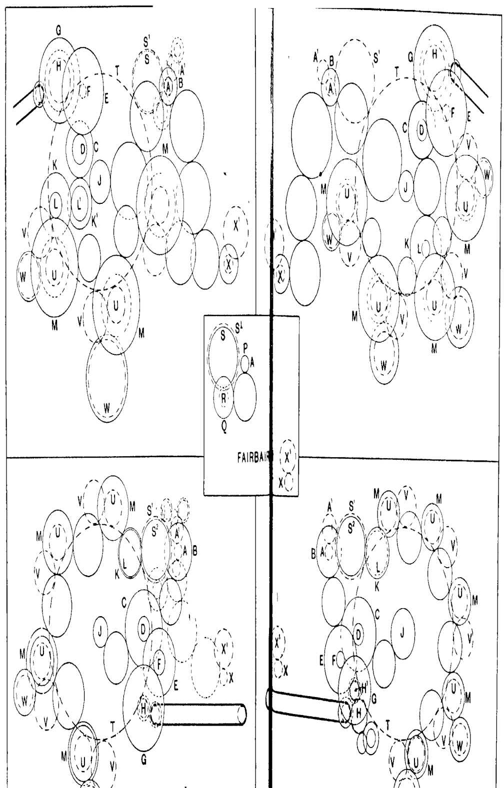


Fig. 1.

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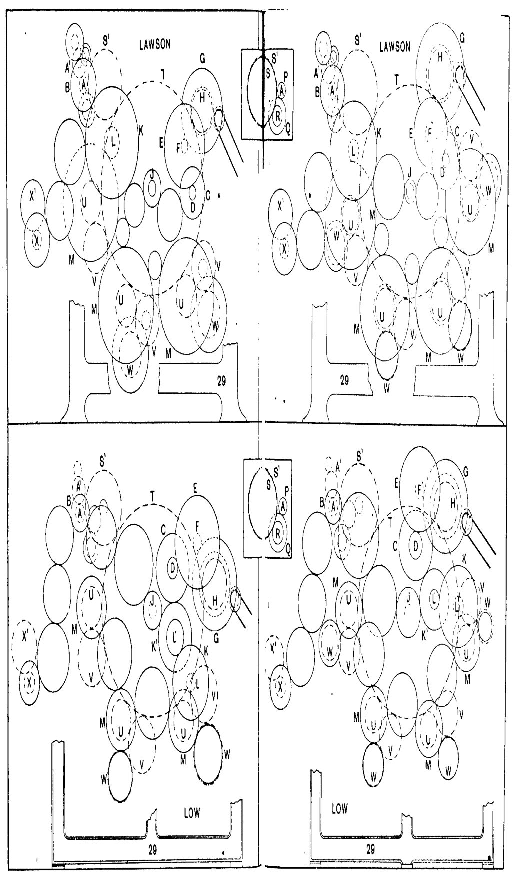

FIG 4.

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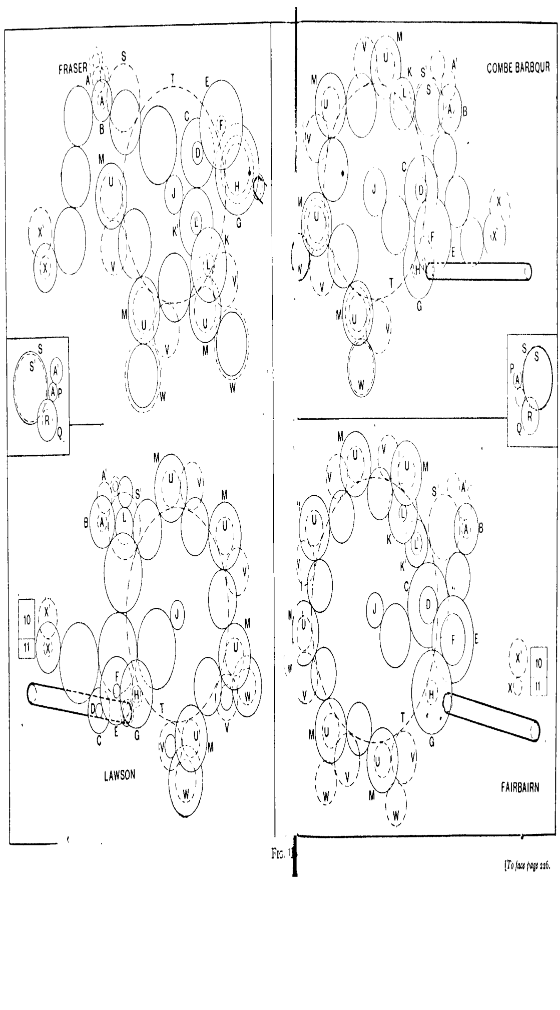

Fig. 1

[To face page 226.

the change wheel; the equivalent of K is represented by the wheel marked S on the other side of the doffer. Thus—

$$(133)\quad \text{Revs. of A} \times \frac{P}{Q} \times \frac{R}{S} \times \frac{L}{M} = \text{revs. of worker.}$$

Where the diameter of the doffer in increased—and this is done in some cards—the number of teeth in the wheel S is increased in the same ratio.

CHAPTER XV

PINS AND PINNING

The illustrations which have been introduced in connection with breaker and finisher cards, and the data concerning the design of the cards, together with the gauging and other details, are calculated to convey a reasonable impression of the machines and the functions which they have to perform. But the information supplied deals chiefly with methods and principles, and it is necessary to particularise when any definite type of work has to be accomplished.

The class of work which one expects to be delivered from the cards, and which will be delivered, depends partly upon the condition of the machine, partly upon the relative speeds of the various rollers, and partly—and perhaps mostly—upon the condition of the pins in the clothing of the various rollers.

When one considers the nature and amount of work which has to be performed by the pins as a whole, and particularly by the pins of the cylinder, one is not surprised to find that a considerable amount of wear and tear takes place, and that the constant friction between the fibres and the pins is exceptionally severe on the pins of the cylinder of the breaker card, and in a lesser degree on the corresponding pins of the finisher card.

The particular way in which the pins are worn by constant work, and the positions of the worn parts, are emphasised in Fig. 136. This is a photo-micrograph of a number of pins which have been removed from the staves of cylinders in breaker and finisher cards. Pins Nos. 1 and 5 are from the latter, while Nos. 2, 3, 4, and 6 are from the former.

It will be observed that the very sharp points with which new pins are provided have been completely worn off the pins reproduced in the illustration, and that a second point of a kind has been formed on each pin; also that there has been a considerable amount of wear

on the front and sides of the pins. In Nos. 4 and 6 there are three grooves.

So long as the pins remain even as illustrated they will continue to split up the stricks and to comb them, but it will be evident that the manner in which these operations are performed by worn pins will be different from that which will obtain when the pins are in a perfect condition and possess the correct taper from the root to the point. The smooth pins can force their way through the stricks, but the grooves which appear in the pins after a period of use, and as exemplified in Fig. 136, have a tendency to hold for a time short lengths of fine fibre; these fibres collect, and when removed at some

1 2 3 4 5 6

FIG. 136

moment in the cycle of operations, are deposited in small bunches termed "neps." The presence of these neps imparts an unsightly appearance to the yarn, introduces trouble in subsequent processes, particularly in the weaving of very heavy cloth, and results in an inferior finished product; while the fault thus produced by the accumulation of small fibres, first in the grooves in the pins and ultimately as neps in the yarn, is obviously due to delay in reclothing the card.

A periodic renewal of the pins is essential in order to produce satisfactory work, and the time which is allowed to lapse between successive renewals will depend not only upon the class of material which is being carded, but also upon the class of pins with which the staves are filled.

The practice observed in most of the mills is to fix a regular period between successive renewals, the time thus fixed having been decided upon as a result of observations and experience in general. When the life of a pin, so far as its effective use is concerned, has been found, arrangements are made to establish fixed periods for a systematic renewal of the pins. And since the particular requirements of the different mills may call for rather different methods, it would be unwise to state any definite time for the renewal of pins on any individual card or system of cards. It is well known, however, that it has been found necessary in some cases to change the cover of the cylinder of the breaker card entirely, or to renew all the pins every six months.

If, however, after six months' work the pins are worn as shown in Fig. 136, it will be obvious that practically all the pins will be in the very worst condition with regard to the production of a satisfactory sliver, and that this gradual deterioration of the pins, which decreases the efficiency of the combing action, will date from the time when the first grooves commenced to be made in the previously perfect pins. Hence, instead of renewing all the pins at one time, it appears to be a much more satisfactory method, in regard to this type of clothing, to complete the renewal in stages, such stages being spaced apart to suit the local conditions. Thus, one quarter of the pins might be renewed every six weeks, or half the pins every three months, while the best work would probably result where the complete renewal was done in the maximum number of stages. Any method of intermittent partial clothing as suggested would enable a certain proportion of the covering to be in quite good condition during practically all the time that the card was in work.

The pins in the finisher cards will require a somewhat modified system of renewal; but, in general, the pins are subject to the same kind of wear, and must be attended to regularly to keep up the quality of the slivers. The pins in the workers, strippers, and doffer must also receive attention, so that all the parts may, as far as possible, maintain a high standard of efficiency in the cycle of operations.

It is equally important to see that the gauging between the various rollers is accurate and correct, and that all the rollers are as clean as possible and running freely in their bearings. The speeds

of those which are driven in relation to each other by wheel-gearing will, naturally, maintain their relative values no matter what fluctuations there may be between the main driving pulleys and belt. On the other hand, the strippers, which are driven, as already demonstrated in Figs 96 to 98 and 104, by an endless belt which grips only a small section of some of the pulleys, are subject to variations, and since there is a tendency for dust to collect on the surfaces of the belt during the working of the machine, any little irregularity in this flexible drive, due to these or other causes, may result in a slower speed of the stripper, with a consequent inefficiency of work.

The correct adjustment of the shrouding and the boxing will aid materially in the production of good work. That part of the boxing on the breaker card which is concentric with the cylinder (see Fig. 72), and extends from the doffer cover to the feed roller, should be fitted very closely to the points of the pins of the cylinder. In the same way, the boxing at the front of the finisher card, and in the same relative position as the above, must fit closely to the pins of the cylinder. The stripper box must be set correctly to the tin cylinder in order to prevent an undue amount of waste, while all the boxing should be made of clean pine, fixed firmly in position, and braced stiffly to prevent spring.

Since all these points require careful adjustment and supervision, it is desirable that there should be a responsible person in this department to attend to these details, for if the work be done carelessly and indiscriminately, the resulting slivers will be unsatisfactory. Moreover, the carding department will yield the best results when careful and generous treatment is practised, and when each one engaged in it is made conscious of his or her own importance as a unit in the production of a perfect yarn.

There is another phase of the subject which affects both the production and the character of the work, and that is the position of the pins themselves in the staves. The best results are likely to be obtained when the pins are arranged in the staves, or "grouped," as it is technically called, to give the maximum amount of cutting according to the number of pins in the stave or the number per square inch. They should be arranged so that they will act on as much of the fibre as is possible with regard to the width. Even

when a minimum number of pins is used per stave—and there are great differences in the numbers used,—they may be arranged in groups which will cover effectively as much of the surface in carding as is considered desirable or advantageous for the character of the work.

Fig. 137 has been drawn diagrammatically to illustrate a few different methods of grouping. All the pins are shown the same thickness and equal proportionately to the thickest pins used. The actual wire-gauge numbers will be stated in the specifications of card clothing.

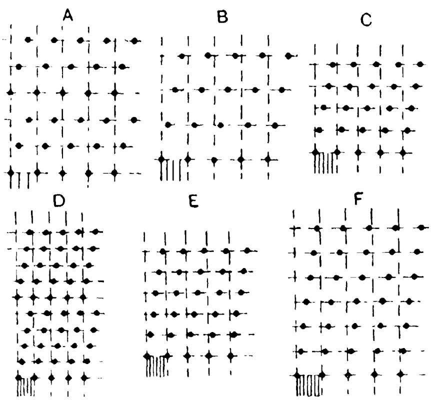

FIG. 137.

At A the grouping is in threes, as indicated by the three short solid lines at the left-hand bottom corner; two units of the grouping appear in the vertical direction and five units in the horizontal direction. The same number of units in the horizontal direction is shown in each diagram. The dots at A represent the positions of the pins for the cylinder of a breaker card, and the dotted lines indicate that the pitch of the pins is $\frac{5}{8}$ in. by $\frac{5}{8}$ in. The pins are medium thickness.

At B the grouping is in fours, and is again for the cylinder of a breaker card. There is one unit of the grouping in the vertical direction, while the pitch of the pins is $\frac{5}{8}$ in. vertical and $\frac{13}{16}$ in. horizontal, and the pins are thick ones.

At C the grouping is in fives; the pins are thick and for a worker. There is one unit of the grouping in the vertical direction, and the pitch of the pins is $\frac{1}{2}$ in by $\frac{1}{2}$ in.

At D the grouping is in fives; the pins are small, and the arrangement is for the cylinder of a finisher card. There are two units of the grouping in the vertical direction, and the pitch of the pins is $\frac{3}{8}$ in. by $\frac{3}{8}$ in.

At E the grouping is in sixes; the pins are thin, and the scheme is for the cylinder of a finisher card. There is one unit of the grouping in the vertical direction, and the pitch of the pins is $\frac{1}{2}$ in. by $\frac{1}{2}$ in.

At F the grouping is in sevens; the pins are medium, and arranged for the cylinder of a breaker card. There is one unit of the grouping in the vertical direction, and the pitch of the pins is $\frac{5}{8}$ in. by $\frac{9}{16}$ in.

The above are simply a few selections to indicate the orders of grouping. A great variety of card clothing is used for practically the same class of work.

It must also be remembered that although many spinners may be making yarns of the same size or count, the class of fibre which is being employed for such a count may vary considerably in the different mills, and this in itself is a factor in the choice, not only of the clothing, but also of many other considerations

In dealing with card clothing it is obvious that, in view of all these variations, one is handicapped to a certain extent in regard to pinning alone, for it is only safe to assess the true value of one covering in comparison with another covering when all the other factors are approximately constant It is therefore wise to remember that there are three points of action in carding which are changeable or variable—speed, gauging, and pinning,—and that if a definite type of clothing be made for all cards in work for slivers to be spun into the same count of yarn, there would still remain two points at which suitable changes could be made to meet all individual opinions regarding the necessary conditions for the production of high-class carded fibres.

The diagrams in Fig. 137 indicate that the pitch of the pins may be as wide as $\frac{3}{4}$ in. or as little as $\frac{1}{4}$ in., depending upon the kind of card roller in the card. When the pitch is $\frac{3}{4}$ in. by $\frac{3}{4}$ in., there will be—

$$(134) \qquad \frac{1 \text{ sq in.}}{\frac{3}{4}\text{ in.} \times \frac{3}{4}\text{ in.}} = \frac{4}{3} \times \frac{4}{3} = \frac{16}{9} = 1\cdot\dot{7} \text{ pins per sq. in.};$$

while in other cases there will be—

$\frac{11}{16}$ by $\frac{11}{16}$ pitch :	$\frac{16}{11} \times \frac{16}{11} = \frac{256}{121}$	$= 2{\cdot}11$	pins per sq. in.	
$\frac{3}{4}$,, $\frac{5}{8}$,, :	$\frac{4}{3} \times \frac{8}{5} = \frac{32}{15}$	$= 2{\cdot}13$	,,	,,
$\frac{5}{8}$,, $\frac{5}{8}$,, :	$\frac{8}{5} \times \frac{8}{5} = \frac{64}{25}$	$= 2{\cdot}56$	,,	,,
$\frac{9}{16}$,, $\frac{9}{16}$,, :	$\frac{16}{9} \times \frac{16}{9} = \frac{256}{81}$	$= 3{\cdot}16$	,,	,,
$\frac{1}{2}$,, $\frac{1}{2}$,, :	$\frac{2}{1} \times \frac{2}{1} =$	$4{\cdot}00$	,,	,,
$\frac{3}{8}$,, $\frac{3}{8}$,, :	$\frac{8}{3} \times \frac{8}{3} = \frac{64}{9}$	$= 7{\cdot}11$	,,	,,
$\frac{1}{4}$,, $\frac{1}{4}$,, :	$\frac{4}{1} \times \frac{4}{1} =$	$16{\cdot}00$	,,	,,

The staves for the cylinders of breaker cards are commonly arranged with pins the pitch of which varies from $\frac{3}{4}$ by $\frac{3}{4}$ to $\frac{9}{16}$ by $\frac{9}{16}$; these, according to the above table, represent from $1{\cdot}\dot{7}$ to $3{\cdot}16$ pins per sq. in. of surface.

The area of the cylinder cover for an ordinary 4 ft.-by-6 ft. cylinder, measuring $49\frac{1}{4}$ in. over the wooden staves, and reckoning the full width of 6 ft., will be—

(135) $\quad 49{\cdot}25 \times 3{\cdot}1416 \times 72$ in. $= 11{,}140$ sq. in.

Hence the total number of pins in the cylinder will be—

Number of square inches $\times$ pins per square inch $=$ total number of pins.

Therefore if the pitch be $\frac{3}{4}$ by $\frac{3}{4}$, as in the coarsest mentioned in the above table, there will be—

(136) $\quad 11{,}140 \times 1{\cdot}77 = 19{,}718$ pins;

while with the other extreme of pitch, $\frac{9}{16}$ by $\frac{9}{16}$, the result will be—

(137) $\quad 11{,}140 \times 3{\cdot}16 = 35{,}202$ pins.

Thus the effect of the carding due to the pins alone with the pitch of $\frac{9}{16}$ by $\frac{9}{16}$ as compared with the pitch of $\frac{3}{4}$ by $\frac{3}{4}$ would be nearly two to one, provided, of course, that the grouping in the two cases was the same.

With a cylinder speed of 180 revs. per min. the number of

contacts between the fibres and the pins in one horizontal line would be—

(138)	$\frac{3}{4}$ by $\frac{3}{4}$ pitch .	19,718 × 180	3,549,240
	$\frac{5}{16}$,, $\frac{9}{16}$,, .	35,202 × 180	6,336,360

—results which appear incredible in connection with comparatively coarse pins and grouping, and which show an increase in carding in the finer clothing over the coarser clothing which is hardly realisable.

The subject of carding is an important and extensive one, and since experts differ greatly in regard to the best means to be adopted for production consistent with good workmanship, it is well-nigh impossible to fix upon an unassailable basis with regard to the system of pinning; at the same time much may be gained by a reasonable exposition of the methods in vogue and by suggestions of various kinds.

We enter upon the subject with a full knowledge of many of the difficulties which are in the way of a definite settlement of a much disputed subject, and are well aware that we are inviting criticism from various sources; nevertheless, the discussion of the subject is bound to bring about more definite ideas about pinning, and will, we hope, lead to a helpful solution of a problem which has perplexed many of those who have not had the opportunity of testing what appeared to be plausible theories.

From the beginning of the last century, when the late Mr William Brown commenced his experiments on the carding of tow, up to the present time, it might be said that, with few exceptions, card coverings vary not so much from the ideas of those in charge as to precedent.

When a carder is in difficulties, or when he wishes for any reason to make some change with the object of improving his output, it is a common practice to discuss with other members of the trade the various points in the process. And if he is successful with his object, and tabulates the information which he has gleaned, with the full knowledge that each carder appears to have his machines working efficiently as far as can be seen, and that therefore the pinning, speeds, and gauging are apparently correct, he will in most cases come to the conclusion that it is unnecessary to make any radical change, because one or other of the points discussed will probably

be similar to his own. And one can scarcely blame him for being reluctant to make a great change, because there is always the chance of the new conditions being worse than the old. Of course, such a procedure may not point much in the direction of development to an inquiring mind, but it possesses the element of safety for a time, and hence the fact remains that the conditions regarding the work vary very little in most places over considerable periods. The machine makers can always recommend a satisfactory covering for ordinary work, but it is natural to assume that they themselves are guided by the experience and advice of their clients, and thus when any particular arrangement gives satisfactory results, the matter may end there for the time.

A statement of part of what has already been done in regard to pinning may help to show that some of the above statements may be relied upon. A long association with the jute trade, and a list of accumulated facts, would enable one to make comparisons of the existing systems, and in doing so some very curious results would be disclosed.

For example, the pitch of the pins in the coverings of the cylinders for breaker cards engaged in the making of slivers for 8 lb. yarn (which may be taken as the basis of the jute-spinning industry) varies from $\frac{3}{4}$ by $\frac{3}{4}$ to $\frac{9}{16}$ by $\frac{9}{16}$, as already shown. If these two limits of covering give equally good results—and the spinners evidently think they do, or a change would be made,—they show that either a wide range of covers is quite suitable, or that the pitch of the pins is not of great importance provided that certain other adjustments are made that would correct any defects of the covering so far as the pitch of the pins is concerned. In addition to these diverse spacings for use in connection with slivers for 8 lb. yarn, it is well known that slivers for many other counts of yarn, and differing widely, may also be carded on these machines with apparently satisfactory results. This also indicates that other conditions may influence the actual result.

If all these statements of facts and the deductions made are admissible, the inertia with regard to pinning is explained to some extent. Notwithstanding this platform of safety, we enter into the discussion with the hope of providing the nucleus of a possible base for card covering or clothing.

At the outset there will be a few objections which might be seriously urged against the adoption of any standard system of pinning. The first may be that the usefulness of a machine is measured in some degree by the range of articles which can be produced by it without any costly and lengthy alterations. But this objection is at once met by the fact that all kinds of pinning seem to give good results. And even if the different kinds of pinning do appear to give results, it does not follow that the subject is unworthy of further inquiry, or that the last word has been said regarding the possibilities of research on the subject.

Another objection may be the fact that the jute fibre varies in different seasons. This, however, provides one of the best arguments in favour of standardisation of the pinnings: first, because there must be repetitions of the variation over succeeding periods of time; and second, because if a suitable standard were found and adopted it would be possible to eliminate one of the present factors which have to be considered and altered when the nature and quality of the fibres change. It will be evident that if a satisfactory standard equipment of the staves or clothing could be established, the speeds and gauging alone would require attention, and consequently the carding might be more perfect and more easily understood or successfully conducted.

In our explanation of the necessary requirements for the operation of carding we mentioned the desirability of securing uniformity in the length and diameter of the fibres which are considered most suitable for use in the production of an approximately perfect thread.

To fulfil these requirements as completely as possible it is not unreasonable to assume that, for a definite count or number of yarn made from a particular quality of fibre, some standard dimensions of that fibre would result in a yarn which would be superior to that of any other yarn made under different conditions And if this assumption is correct, we venture to say that a particular scheme of card clothing or covering would be correct, and that any other dimensions of clothing for the same working conditions would be wrong, or at least not so satisfactory.

Although it has already been shown that experience proves the possibility of achieving approximately equal results from widely different conditions, we would suggest that a fair basis of propor-

tioning the pins in the staves of the clothing of a card would be the count or number of the yarn—or a limited range of counts—for a definite quality of material.

If the foregoing explanations are conceded, it follows that the dimensions of the fibres should be proportional to the threads they constitute. To attain these conditions perfectly, it would be

Pitch Round the Circumference		Pitch Across the Roller.	No. of Pins per Sq. In.
$\frac{3}{4}$	by	$\frac{3}{4}$	1·77
$\frac{11}{16}$	,,	$\frac{11}{16}$	2·11
$\frac{5}{8}$	,,	$\frac{5}{8}$	2·56
$\frac{5}{8}$	,,	$\frac{9}{16}$	2·84
$\frac{5}{8}$	,,	$\frac{1}{2}$	3·20
$\frac{5}{8}$	,,	$\frac{7}{16}$	3·65
$\frac{9}{16}$	,,	$\frac{9}{16}$	3·16
$\frac{1}{2}$	,,	$\frac{9}{16}$	3·55
$\frac{1}{2}$	,,	$\frac{1}{2}$	4·00
$\frac{1}{2}$	,,	$\frac{7}{16}$	4·57
$\frac{1}{2}$	,,	$\frac{3}{8}$	5·33
$\frac{7}{16}$	,,	$\frac{7}{16}$	5·22
$\frac{3}{8}$	,,	$\frac{7}{16}$	6·09
$\frac{3}{8}$	,,	$\frac{3}{8}$	7·11
$\frac{3}{8}$	,,	$\frac{21}{64}$	8·12
$\frac{3}{8}$	,,	$\frac{5}{16}$	8·53
$\frac{5}{16}$	,,	$\frac{5}{16}$	10·24
$\frac{9}{32}$	,,	$\frac{5}{16}$	11·37
$\frac{9}{32}$	,,	$\frac{9}{32}$	12·64
$\frac{5}{16}$	,,	$\frac{1}{4}$	12·80
$\frac{9}{32}$	,,	$\frac{1}{4}$	14·22
$\frac{1}{4}$	,,	$\frac{1}{4}$	16·00
$\frac{1}{4}$	,,	$\frac{7}{32}$	18·28
$\frac{7}{32}$	,,	$\frac{7}{32}$	20·89
3 pins per inch each way			9·00
$3\frac{1}{2}$,, ,, ,,			12·25
4 ,, ,, ,,			16·00
$4\frac{1}{2}$,, ,, ,,			20·25

essential that the fibres or filaments which enter into the composition of a certain yarn should be of uniform length and uniform diameter, so that if a number of transverse sections were made from different parts of the thread there would be exhibited the same number of fibres in each. Any irregularity in this particular, or any variation in the length and thickness of the fibres, would affect the thickness as well as the strength of the yarn. The perfect conditions thus explained are in practice unrealisable, but the nearer the actual conditions approach this ideal state the more perfect will the yarn be in every particular.

As a natural consequence, the cutting and combing of the raw material for the production of slivers for thin yarns should be conducted by a large number of pins arranged to give an extensive scheme of splitting or separation; while, on the other hand, the material for the slivers for heavy yarns will be made satisfactorily by a much fewer number of pins in the clothing.

These arguments seem to contradict certain modern experience, and get right in the way of a development which is now taking place in the production of slivers for sacking weft; this apparent contradiction holds good only under certain conditions which shall be discussed when reference is made to the making of this type of yarn.

Since there is such a diversity of pinning, the various arrangements of the pins in the rollers of breaker and finisher cards should claim particular attention. We therefore introduce, first, a table which embraces practically all the different pitches with the corresponding numbers of pins per inch, and, later, different lists embodying the pitches in all the rollers of several schemes of card clothing which have come under the notice of the authors.

The number of pins per square inch can be taken from the above table for any of the pitches which are enclosed in the undermentioned particulars of card coverings, and a comparison between these existing types will elicit the usual methods of dealing with the clothing of breaker and finisher cards, and should also provide much to interest those engaged in the trade.

PITCH OF PINS IN BREAKER CARDS.

No	Cylinder	Feed	Workers	Strippers	1st Doffer.	2nd Doffer.
1	$\frac{3}{4} \times \frac{3}{4}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	—
2	$\frac{3}{4} \times \frac{3}{4}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{3}{4} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$
3	$1\frac{1}{16} \times 1\frac{1}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	—
4	$\frac{5}{8} \times \frac{5}{8}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{3}{8} \times \frac{3}{8}$	—
5	$\frac{5}{8} \times \frac{5}{8}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{5}{16}$
6	$\frac{3}{4} \times \frac{3}{4}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{3}{8} \times \frac{3}{8}$	—
7	$\frac{5}{8} \times \frac{9}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{3}{8} \times \frac{5}{16}$	—
8	$\frac{9}{16} \times \frac{9}{16}$	$\frac{7}{16} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	—
9	$\frac{5}{8} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{3}{8}$	—
10	$\frac{5}{8} \times \frac{5}{8}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{1}{2}$	$\frac{3}{8} \times \frac{5}{16}$	—
11	$\frac{1}{2} \times \frac{1}{2}$	$\frac{9}{16} \times \frac{1}{2}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{9}{16} \times \frac{1}{2}$	$\frac{1}{2} \times \frac{1}{2}$	—
12	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	—
13	$\frac{3}{8} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{5}{16}$	$\frac{3}{8} \times \frac{5}{16}$	$\frac{5}{16} \times \frac{5}{16}$	—

In giving the pitch of the pins in the table the first number refers to the pitch round the circumference, and the second number to the pitch in the length of the roller.

The following tables should be considered in conjunction with the last two tables of pitches and number of pins per inch on p. 238 and 239.

PITCH OF PINS IN 3-PAIR FINISHER CARDS.

No	Cylinder	Feed.	1st Worker.	2nd and 3rd Workers	1st Stripper	2nd and 3rd Strippers	1st Doffer.	2nd Doffer.
14	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	—
15	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{1}{2} \times \frac{15}{32}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$
16	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{5}{16}$	$\frac{5}{16} \times \frac{5}{16}$
17	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{5}{16} \times \frac{5}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{5}{16} \times \frac{1}{4}$	$\frac{1}{4} \times \frac{1}{4}$
18	$\frac{7}{16} \times \frac{7}{16}$	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16}$ $\frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	—
19	$\frac{3}{8} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	—
20	$\frac{1}{2} \times \frac{1}{2}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{1}{4} \times \frac{1}{4}$	—

PITCH OF PINS IN 4-PAIR FINISHER CARDS.

No	Cylinder.	Feed	1st and 2nd Workers	3rd and 4th Workers	1st and 2nd Strippers	3rd and 4th Strippers	1st Doffer.	2nd Doffer.
21	$\frac{5}{8} \times \frac{5}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{4} \times \frac{3}{4}$	$\frac{3}{4} \times \frac{3}{4}$	$\frac{5}{16} \times \frac{1}{4}$	$\frac{5}{16} \times \frac{1}{4}$
22	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{1}{2} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{5}{16}$	—
23	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{5}{16} \times \frac{5}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{9}{32} \times \frac{1}{4}$	—
24	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{5}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{5}{16} \times \frac{5}{16}$	—
25	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{5}{16} \times \frac{5}{16}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{5}{16} \times \frac{1}{4}$	—
26	$3\frac{1}{2}$ per in. each way	$2\frac{1}{2}$ per in. each way	$\frac{9}{32} \times \frac{9}{32}$	$\frac{1}{4} \times \frac{1}{4}$	$\frac{5}{16} \times \frac{5}{16}$	$\frac{9}{32} \times \frac{5}{16}$	$\frac{9}{32} \times \frac{9}{32}$	—
27	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{5}{16} \times \frac{5}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{21}{64}$	$\frac{1}{4} \times \frac{1}{4}$	—
28	$\frac{3}{8} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{7}{16}$	—
29	$\frac{7}{16} \times \frac{7}{16}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{3}{8}$	$\frac{3}{8} \times \frac{5}{16}$	$\frac{1}{2} \times \frac{3}{8}$	$\frac{7}{16} \times \frac{3}{8}$	$\frac{1}{4} \times \frac{1}{4}$	—

PARTICULARS OF PINS IN 5-PAIR FINISHER CARD: ROLLER FEED.

STAVES FOR CYLINDER . . . $23\frac{5}{8}$ in. × $3\frac{1}{4}$ in.
STAVES FOR OTHER ROLLERS . . $23\frac{5}{8}$ in × $2\frac{1}{2}$ in.

Name of Roller.	Diameter and Width of Roller	Number of Pins per Row	Number of Rows of Pins in Stave	Number of Pins per Sq In
Cylinder	48 by 71	77	11	11 48
Feed	6 ,,	71	7	8 41
Feed stripper . .	7 ,,	71	7	8·41
1st and 2nd workers .	5 ,,	79	9	12·03
3rd and 4th ,, .	5 ,,	83	10	14·04
5th worker . .	5 ,,	89	11	16·56
1st and 2nd strippers .	8 ,,	79	8	10 69
3rd and 4th ,, .	8 ,,	83	9	12·64
5th stripper . .	8 ,,	89	10	15 06
Doffer . .	14 ,,	108	11	20·10

PARTICULARS OF PINS IN 6 PAIR FINISHER CARD ROLLER FEED

STAVES FOR CYLINDER . . . . $23\frac{5}{8}$ in. × $3\frac{1}{4}$ in.
STAVES FOR OTHER ROLLERS . . $23\frac{5}{8}$ in. × $2\frac{1}{2}$ in.

Name of Roller	Diameter and Width of Roller	Number of Pins per Row in Stave.	Number of Rows of Pins in Stave.	Number of Pins per Sq. In.
Cylinder	60 by 71	77	11	11·48
Feed . .	3 ,,	213 in width	28 in round	8·91
Feed stripper . .	7 ,,	71	7	8·41
1st and 2nd workers .	6 ,,	--	Card cloth	18·00
3rd worker . .	6 ,,	--	,,	21·00
4th ,, . .	6 ,,	83	9	12·64
5th and 6th workers .	6 ,,	89	10	15·06
1st and 2nd strippers .	9 ,,	79	8	10·69
3rd and 4th ,, .	9 ,,	83	9	12·64
5th and 6th ,, .	9 ,,	89	10	15·06
1st doffer . . .	14 ,,	--	Card cloth	25·50
2nd ,, . . .	14 ,,	--	,,	40·00

The above tables of card clothing are typical of the covering supplied for breaker and finisher cards made by various machine makers, and should therefore be a guide as to what in practice is considered to be most suitable. They also provide an extensive variety which may be made the foundation of research in regard to the adoption of some standard covering for each particular type of card in general, and from which the essential or desirable modifica-

tions can be adopted in respect of certain ranges of yarn counts. Such a standard covering would also serve as a guide by means of which a satisfactory change in speed or in gauging could be intelligently made on any set of cards, or on any individual card, to achieve the most beneficial results in any special kind of work.

Up to the present there has been little variation in the dimensions of the pins, and the particulars in the following table represent what are generally found in practice :—

—	Breaker Cards.		Finisher Cards.	
	Length of Pin	Thickness B W G	Length of Pin	Thickness B W G
Cylinder . .	1 in	No 12	$\frac{3}{4}$ in	No 14
Feed . . .	$1\frac{1}{8}$ in.	,, 12	—	No 13 to 15
Workers . .	$1\frac{5}{8}$ in.	,, 12	$1\frac{1}{2}$ to $1\frac{1}{4}$ in	,, 13 or 14
Strippers . .	1 in.	,, 13	$\frac{7}{8}$ in	,, 15 ,, 16
Doffers . .	1 in	No 14 or 15	1 in	,, 16 ,, 17

Although the counts of jute yarns range from, say, 3 lb. per spindle to 450 or 500 lb. per spindle, it may be said that in general all counts above 48 lb. per spindle are delivered in what may be called rove, and since these heavy yarns are invariably made from other grades of material, they do not come within the present discussion.

Hitherto it has been unusual to discuss the making of sacking weft along with the ordinary or smaller yarns, but one can hardly neglect these comparatively heavy yarns to-day owing to the recent development in connection with the carding of fibre for use in the spinning of this type of yarn; consequently we have included the whole range in the above tables.

If one or more standards of card clothing were adopted consistent with one or more ranges of yarn counts, the alteration of the speed of the workers, or a change in the gauging between the workers and the cylinder, could be effected instead of changing the covering when a distinct change in the degree of cutting is contemplated.

Some of the particulars in the tables may in certain cases be considered out of date or antiquated by those who have been clothing their cards according to modern specifications; but, curiously

enough, it may be stated that one of the latest covers for a card engaged in producing slivers for ordinary hessian yarns is one of those given in the tables, and of the wide or sparsely pitched type.

An examination of the specifications in regard to breaker cards will show the following :—

3	cylinders	$\frac{3}{4}$	by	$\frac{3}{4}$	pitch,	1·77	pins per sq. in.,	in each,	or	4·31	pins.
1	,,	$\frac{11}{16}$	,,	$\frac{11}{16}$	,,	2·11	,,	,,		2·11	,,
3	,,	$\frac{5}{8}$	,,	$\frac{5}{8}$	,,	2·56	,,	,,		7·68	,,
1	,,	$\frac{5}{8}$	,,	$\frac{9}{16}$	,,	2·84	,,	,,		2·84	,,
1	,,	$\frac{9}{16}$	,,	$\frac{9}{16}$	,,	3·16	,,	,,		3·16	,,
1	,,	$\frac{5}{8}$	,,	$\frac{7}{16}$	,,	3·65	,,	,,		3·65	,,
1	,,	$\frac{1}{2}$	,,	$\frac{1}{2}$	,,	4·00	,,	,,		4·00	,,
1	,,	$\frac{7}{16}$	,,	$\frac{7}{16}$	,,	5·22	,,	,,		5·22	,,
1	,,	$\frac{3}{8}$	,,	$\frac{7}{16}$	,,	6·09	,,	,,		6·09	,,
13										39·06	

(139) and $\frac{39·06 \text{ pins}}{13 \text{ cylinders}}$ = 3 pins per sq. in. over all.

The specification No. 4 in the breaker card list is used extensively for making slivers to be converted into yarns the counts of which vary from 7 lb. per spindle to 20 lb. per spindle; while the specification marked No. 1 is commonly adopted when yarns from 20 lb. per spindle to 48 lb. per spindle are wanted. It will thus be seen that, neglecting the minimum amount of fibre which is used for the finer classes of yarn, say, up to and including 6 lb. per spindle, two distinct specifications are capable of satisfying the needs for the full range of yarns up to and including 48 lb. per spindle. Nevertheless, many managers would probably consider it incorrect to assume that the best results are obtained by covering within these limited ranges.

Since it appears necessary that the combing and splitting of the fibres should be more thorough when light or fine yarns are to be prepared than when the slivers are for the heavier yarns from the same material, it follows that the number of pins per square inch should diminish in some porportion as the sectional area or thickness of the yarn under consideration increases. And since this sectional area of the yarn is circular, the number of pins in use should be inversely proportional to the sectional area, and consequently to the square root of the count of yarn.

If we take the first eleven cylinders in the last table—leaving

out those which are clothed for yarns under 7 lb. per spindle—we get 27·75 pins, or an average of—

(140) $$\frac{27{\cdot}75 \text{ pins.}}{11 \text{ cylinders}} = 2{\cdot}52 \text{ pins per sq. in.}$$

Then, taking the square roots of the two extreme counts, we have—

$$\sqrt{7} \text{ lb.} = 2{\cdot}64$$
$$\sqrt{48} \text{ lb.} = 6{\cdot}93$$

and

(141) $$\frac{2{\cdot}64 + 6{\cdot}93}{2} = 4{\cdot}78 \text{ average.}$$

The average number of pins per square inch taken over the above-mentioned 11 cylinders is 2·52; therefore, using the average number as a base, it follows that a constant number may be obtained as follows :—

(142) $$\text{Pins per square inch} \times \sqrt{\text{count}} = \text{constant number};$$

or

(143) $$\frac{\text{Constant number}}{\sqrt{\text{Count}}} = \text{pins per square inch.}$$

Therefore, according to the first of these two equations, we have—

(144) $2{\cdot}52 \times 4{\cdot}78 = 12{\cdot}0456$; or, say, 12 for a constant.

With regard to the last two cylinders in the latter table, we have—

(145) $$\frac{5{\cdot}22 + 6{\cdot}09}{2} = 5{\cdot}65 \text{ pins per sq. in.,}$$

and, since

(146) $$\frac{\text{Constant number}}{\text{Pins per square inch}} = \sqrt{\text{count}},$$

it follows that

(147) $$\frac{12}{5{\cdot}65} = 2{\cdot}12, \text{ the square root of the count.}$$

$$\therefore \quad 2{\cdot}12^2 = \text{approximately } 4\tfrac{1}{2} \text{ lb. per spindle.}$$

It would, of course, be impracticable to change the number of pins for every change of count; but if the theory holds good, it would appear that when a firm is employed largely on one specified count, it would be advantageous to use this count in the formula,

and to adopt the resulting number of pins per square inch for the clothing of the cylinder.

The card clothing on the workers does not show the same variation as is found on the clothing for the cylinders, but at the same time constant numbers could be found for these by a similar method to that described above. Thus a constant number of 20 to 24 might be adopted for the workers, in which case we should have—

(148) $$\frac{20 \cdot 00}{4 \cdot 78} = 4 \cdot 18 \text{ pins per sq. in.}$$

which is a little finer than the pitch represented by $\frac{1}{2} \times \frac{1}{2}$; and

(149) $$\frac{24 \cdot 00}{4 \cdot 78} = 5 \cdot 02 \text{ pins per sq. in.};$$

or a pitch of about $\frac{7}{16} \times \frac{7}{16}$.

Since the pins in the strippers and in the doffers do not take a great part in the actual combing and splitting of the fibres, it follows that there is not such a wide range of pitches in these rollers as in the cylinder and the workers; sufficient pins are inserted to remove effectively the sheet of fibres at the various points.

CHAPTER XVI

WASTE AND BY-PRODUCTS; SACKING AND OTHER HEAVY WEFTS

ALL the foregoing explanations, illustrations, and details apply exclusively to jute fibre which is treated for the express purpose of preparing the material for the ordinary types of sliver such as are spun ultimately—after having been treated in the drawing and roving frames—into warp and weft which embrace all the light or low counts up to approximately what is known as 20 lb. per spindle. It might just be stated here that this term, "lb. per spindle," has the following significance:—

$$\text{One spindle} = 48 \text{ cuts} = 14,400 \text{ yds.}$$

$$(150) \qquad \frac{14,400 \text{ yds.}}{\text{Jute count}} = \text{number of yards per pound;}$$

hence the jute count is reckoned by the weight in pounds of 14,400 yds.

In addition to the above ordinary yarns, there is a large quantity of yarn made from the by-products, as it were, of the jute, and also from the waste made in the foregoing and in subsequent processes. In short, these by-products embrace rejections, cuttings, rope or bale binders, and various kinds of waste, and the whole is judiciously mixed, more or less intimately, for the preparing and spinning of comparatively heavy weft yarns, to be used in the manufacture of sackings, carpets, and other fabrics of a heavy type.

Since there are so many kinds and qualities of jute fibre utilised in the different classes of yarn, as well as so many different counts of yarn, it is impossible to give exact figures concerning the quantity of waste which is made during the operation of carding. The actual or average waste made when dealing with some specific kind of material could be easily ascertained by periodic observations, but in any experiment or trial of this nature, the time of the year and

the general climatic conditions, must be taken into account, in order to determine the percentage of evaporation of the batching moisture, as well as to ascertain the actual quantity of fibrous matter which leaves the bulk as the latter is passing through the various stages of the process.

One of the reasons for ascertaining the amount of evaporation of the batching moisture is to enable one to make the necessary allowance for this loss by adding the correct amount to the normal weight of the dollop bundle, so that the sliver delivered at the front of the breaker card will be the correct weight for the finisher card. This allowance is often decided upon as a result of past experience; but, on the other hand, the allowance may be made by judgment as to what the waste would be when compared with what is being made at the time by the treatment of the particular class of jute in work. It often happens that more of the loss is due to this evaporation than to the actual loss caused by the detachment of jute fibres from those which pass into the sliver.

A moderately safe estimate for the above loss due to evaporation is from 3 to 15 per cent of the normal weight; in addition to this, however, it may be necessary to increase this percentage owing to what is termed the "lead" which is given in some of the subsequent machines, such lead being allowed for the object of enabling the slivers to move freely on the sliver plates of these machines. It need hardly be said that the condition of the working parts of the machines, as well as the class of machine, will affect the result, and especially will this be the case where the slivers break more often than they should do owing to any difficulties which are in the way of the operatives.

As a result of a considerable number of observations of the actual weight of fibrous waste from the carding machines alone, over stated periods, and for the same length of time, it was found that the quantity varied from 2 to 18 lb.

It has been stated that different classes of batching oils will influence very appreciably the amount of waste. While this may be true to a certain extent, it is advisable for each manager to make definite trials, and thus enable him to draw conclusive opinions. Many of the statements made by dealers in regard to this phase may be advantageous in certain directions, but the result of personal

experience is a much more satisfactory guide than any number of trade advertisements.

With respect to fibrous and other concrete waste, it will be understood that one kind or other is being contracted during the complete course of operations until the yarns are made up ready for dispatch, or for the manufacturer, and, of course, in the winding, dressing, and weaving departments. The waste caused in the various operations will be considered at the different places. In the meantime we mention them as a whole, because it is in the carding department where waste from all sources receives the initial treatment.

Amongst the by-products which have been mentioned as being used for sacking yarns are rejections; these are really fibres, or fibrous materials, which have been separated from the better-class fibres, and are used for the first time in company with waste and the like. The introduction of rejections and ropes helps to add strength to the cuttings and waste, but it will be clear that such a diversity of material as is included in the term " by-products " should receive some form of treatment which differs in the earlier stages from that already described in connection with ordinary stricks of jute.

Much of the waste fibre will be exceedingly short, and hence the conditions which were suggested as suitable for ordinary yarns in regard to length and proportionate diameters must, or should, be modified with reference to the spinning of the above heavy yarns. The remarks in regard to length and proportionate diameters apply where the fibre is of reasonable length, but they cannot be considered correct for waste fibres, because the latter are in general very short and small fibres which have left the bulk in the various processes through which the material passes in its conversion from fibre to cloth or from fibre to yarn.

In order to approach that stage of ratio between length and diameter for the purpose of making a uniformly level thread of the greatest strength obtainable with regard to the material at our disposal, it will be necessary first to adopt an extended process of carding, and then, in order to secure a strong thread, it will be essential to give more turns per inch (technically termed " twist ") to the yarn in proportion to its size or count than what is considered sufficient or recommended for yarns which are made from the better grades of fibre.

It may be noted here that although the twist, or the number of turns per inch, on any given yarn for a specified purpose may be correct, say for a standard quality of material, it will probably be necessary to alter the twist for the same count of yarn if the quality of the material is changed These remarks anticipate further operations, but it is desirable that some explanation should be forthcoming at this stage

The strength of a yarn depends partly upon the quality of the constituent fibres, and partly upon the friction generated between them; if this friction is less than the tensile stress, it is evident that the fibres will slide on each other, and ultimately the yarn will give way. The degree of friction, in its turn, will depend upon the roughness of the fibres, and upon the number and kind of convolutions which each fibre makes with the remainder of the fibres; this latter fact alone demonstrates the necessity for comparatively long fibres for thick or heavy yarns, unless these natural demands can be met by some other exigency—e g, by the above-mentioned practice of imparting a comparatively large amount of twist to those heavy yarns which are made from short fibres.

Reverting to the two essentials, it may be stated that the first process—that of an extended scheme of carding - is desirable in order to card the long fibrous material of the mixture into lengths which approximate more nearly to the shortest fibres than do those ordinary and better lengths of jute fibre which have been obtained by a similar but less extended process of reduction in length. The second process, that of applying more twist than usual, is then absolutely essential if any reasonable strength is to be obtained. In a word, it is wise to card very finely if one desires to approach uniformity in fibre; and it is advisable to employ more cards in a system than it is usual to do in order to increase the degree of uniformity. It need hardly be mentioned that at first sight these drastic alterations in carding and spinning point to a great decrease in the production of yarn.

One method which is largely practised is to pass most of the raw material through what is known as a " teaser-card " or " devil." The pins in this machine open out the ravelled fibrous material, and reduce the larger and rougher pieces into a tow, and all is delivered in the latter form.

Fig. 138 illustrates the form of teaser-card which it is usual to employ for these waste materials and by-products. The mixture is laid in the usual way on the travelling sheet on the left, but, after it has passed through the machine, it is delivered on to the floor instead of into a sliver can as in the breaker card. The chute or guide is shown clearly on the right immediately under the drawing

FIG 138

roller. This view of the machine made by Messrs. Douglas Fraser & Sons, Arbroath, is introduced specially to illustrate the compact way of boxing-in practically all the machine. The solid slides were moved a short distance before the photograph was taken, in order to display part of the gear side of the machine. Thus the reader will recognise the cylinder pinion (second wheel down) and part of the gearing to the two workers, as well as a small part of the gear to the drawing roller. A few change pinions are lying in a pile on the floor.

The pulley side of a somewhat similar machine, but with the ordinary type of cage-guard, appears in Fig. 139. In this case the mixture of fibrous material is seen clearly on the left, and the pile of ejected tow is equally prominent on the right.

After all the mixture has been converted into a more or less homogeneous mass, as illustrated at the delivery end of Fig. 139, it is removed and then fed into a second carding machine, from which it is delivered in the familiar form of a sliver, finally the slivers from these cans are utilised in one or other of the two methods

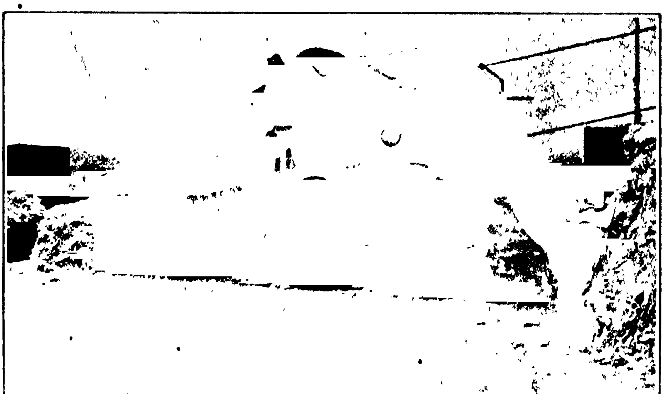

FIG 139.

already fully described and illustrated in connection with finisher cards. In some cases it is preferred to card the waste and cuttings on one card, and the ropes and rejections on another card, and then use the separate tows in definite proportions for the final sliver. This mixture would be treated with the middle card of the system suggested farther on.

Attention has already been drawn to the fact that during the operations of carding certain amounts of impurities are removed from the fibrous materials at the various points, and along with these impurities a quantity of fibre leaves the bulk; this mixture forms the usual type of carding waste. It is practically impossible to avoid this waste at the card itself, but the fibres which are dis-

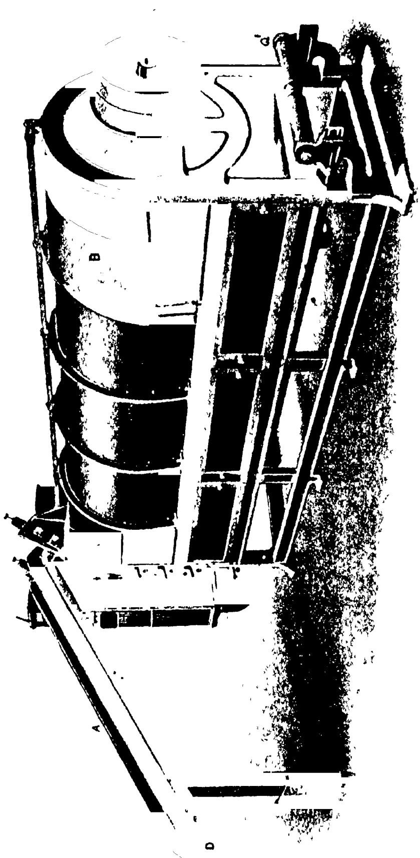

FIG. 140.

charged in this way are capable of being removed from the card waste, and finally used in the preparation of slivers for other classes of yarn.

The card waste is withdrawn from under the card at suitable intervals, and placed either in bags or in light basket carts for easy conveyance. These receptacles are sometimes taken into a special room apart from the rest of the machines because of the risk of fire; the contents may then be treated at opportune times.

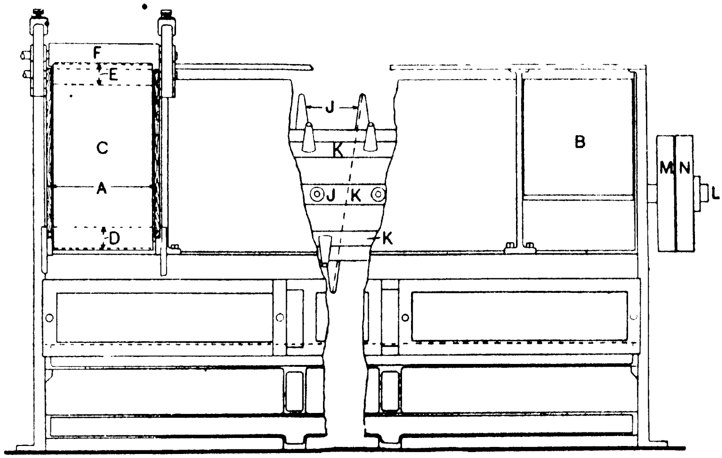

FIG. 141.

The recovery of the fibre from the card waste is performed by the aid of a machine termed a "dust shaker" or "waste cleaner," and such a machine is installed in every modern mill. The type of machine or apparatus used may be of very simple design, or of a more or less elaborate design, and it will be understood that there are several types in use. It is only natural to expect, however, that the machines which are designed specially for efficiency and production will give the best results from every point of view.

A perspective view of one of the latest kind of such machines is illustrated in Fig. 140. In general, the machines are from 8 ft. to 12 ft. in length, and provided with a feed-table A at one end

by means of which the waste, after having been fed on to a travelling feed sheet, is conveyed to the feed rollers in much the same manner as in the breaker card. After the material has been treated and simultaneously conveyed gradually to the opposite end of the machine—the driving-pulley end—it is discharged from the canopy B.

Fig. 141 is a front elevation showing the feed and delivery ends, and part of the interior mechanism. The low rollers of the con-

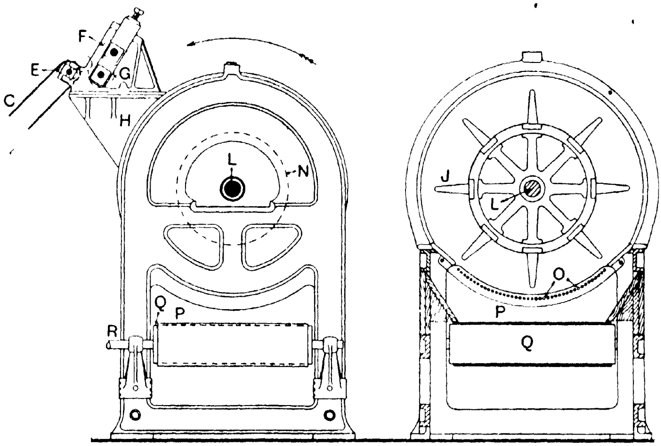

FIG. 142. FIG. 143.

veyor are not shown in this figure, but one of them is sufficiently well illustrated in Fig. 140, while the other is shown in the elevation of the opposite end of the machine in Fig. 142, as well as in the sectional elevation in Fig. 143.

The feed table A is supported in the usual way (see Fig. 140), and the feed cloth C passes over the rollers D and E, Fig. 141, so that the endless travelling feed cloth may convey the waste material to a pair of fluted rollers, the upper one F only being visible in Fig. 141, but this and the lower roller G are shown in Fig. 142, and the ends of their shafts in Fig. 140. Fig. 142 is a different-hand machine from that illustrated in Figs. 140 and 141.

After the waste material emerges from the fluted rollers F and G, it falls into a kind of hopper H, and is caught by the pins J (see Figs. 141 and 143). These pins, which are shown rounded off, but which are generally slightly bent, are arranged spirally around the central shaft or cylinder, and fixed to the eight flat bars K. The drum is rotated by the central or main shaft L, and placed in and out of action by the fast and loose pulleys M and N on the shaft L. The pins open out the waste material, and the internal parts cause it to be conveyed from the feed end to the delivery end. During this time most, if not all, of the foreign matter escapes through a grid O, Fig 143, formed by a series of $\frac{5}{8}$ in. diameter round rods placed at a distance apart to allow only the impurities to drop out

The dust thus separated falls on to a travelling cloth P, the upper and lower widths being represented by solid black in Fig. 143, and passing partially round the roller Q in Fig. 142. The shaft R of the roller Q usually carries a bevel-wheel which is suitably driven by wheel-gearing from the main shaft L, although in some cases a belt drive is employed The gearing is also extended to the upper part of the machine to drive the feed rollers, and all the parts are securely cased in as demonstrated in Figs. 140 and 141. The roller Q^1 at the pulley end in Fig. 140 is capable of being adjusted laterally so as to impart the necessary tension to the belt.

In some cases a recess in the floor is made immediately under the delivery roller Q^1 at the pulley end to hold a bag into which the dust drops, while in other cases a second conveyer is arranged at right angles to the prime conveyer P so as to convey the dust into some more convenient place, and to discharge it into bags at a more suitable level with regard to the floor.

The direction of motion is indicated by the arrow in Fig. 142, while Figs. 140 and 141 show the complete and efficient covering which not only prevents the scattering of the dust in the room, but provides easy access to all important parts. The central shaft L is of substantial construction, and carries the rings to which the above-mentioned longitudinal flat bars K are fixed, while the structure, which is an improvement on the older types, is designed with a view to cleanliness and safety.

The description of carding would not be complete without some

reference to what is sometimes termed "double delivery" from the finisher cards. This type of delivery is adopted to facilitate the supply of material to the first type of drawing frame—*i. e.*, the "push-bar" or the "chain" frame—and so minimise the number of sliver cans at the back of the machine. To effect this reduction of cans it is necessary to introduce "double slivers" in the cans, and Fig. 144 illustrates how this operation is accomplished. It will be noticed from the figure that the finisher cards are fed from laps or balls; the laps are clearly shown in iron frames or stands

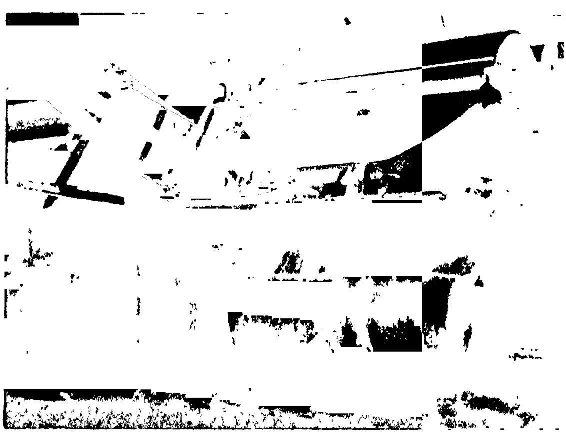

FIG. 144.

near the floor. The respective slivers from the two finisher cards —part only of that on the left being visible—are shown descending into the can on the extreme left, and it will be observed that the fibrous film which leaves the drawing roller enters into a full-width conductor.

Objection might be taken to such a method of combining two slivers from two finisher cards, because of the difficulty experienced in getting the two machines to work in unison with regard to the delivery of slivers. If any irregularity obtains, different weights would result, and this would be more or less disastrous. Satisfactory results may, however, be achieved with care.

Larger sliver cans may be used, and since fibre-cans have become so popular, wear and tear may be reduced considerably. The above method of delivery, although not extensively adopted, utilises space, and prevents crowding of the cans at the first drawing frame; it also facilitates the work of the operatives--a highly commendable consideration when good work is expected or desired.

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somewhat, because every phase of the subject should not be overshadowed by the actual weight of sliver which is produced It might, for example, be as profitable, and even perhaps more profitable, to produce from the same machinery 20 cwt. of good yarn with a minimum amount of waste, as to produce 25 cwt. of indifferent yarn with a maximum of waste It must be borne in mind that waste started on its journey through the machines usually causes more waste, and hence it is quite possible to have a large amount of this material in continual circulation throughout the various departments of the industry.

The fibrous material should be well opened out and prepared for the second stage of carding, and we might suggest that, for the second and third cards, smaller rollers than usual should be adopted. If the material is well opened at the first machine, there would not be much trouble at the second machine, where the covering and gauging of the rollers could be arranged to produce a well-carded and uniform sliver. By the use of the machines specified above, the carding or cutting of the fibre would be distributed over a series of rollers, which would be able to produce a more satisfactory sliver than is possible with the ordinary methods of carding for such yarns.

For many years the advocates of reform in regard to the methods of carding have considered the subject carefully, and the few experiments which followed, and which were conducted as a result of this consideration, have been attended with varying degrees of success. The difficulties to be encountered in any scheme of experimental work by individual firms or persons are well understood, and the best results are calculated to obtain when concerted action takes place.

In addition to the suggested base with regard to pinning, there is also the subject of the length and thickness of the pins, and the distance which the pins should project above the periphery of the various rollers. This phase of the subject came under discussion when the photographs were being prepared for the illustration of the appearance of the fibres on the various rollers—we refer, of course, to Figs. 81, 82 and 83, pp. 152 to 159. As a result of this discussion an experiment was conducted by the authors which may have some bearing on this subject, although it is

not suggested that the results are in any way conclusive. The deductions from the experiment may vary, and more extended researches would have to be instituted before any definite conclusion could be safely made.

A few heads or stricks of ordinary jute were dyed black, and a similar number of very light-coloured jute was selected to work along with the black jute. A breaker card was run until the delivery of the material already in the card ceased absolutely, and,

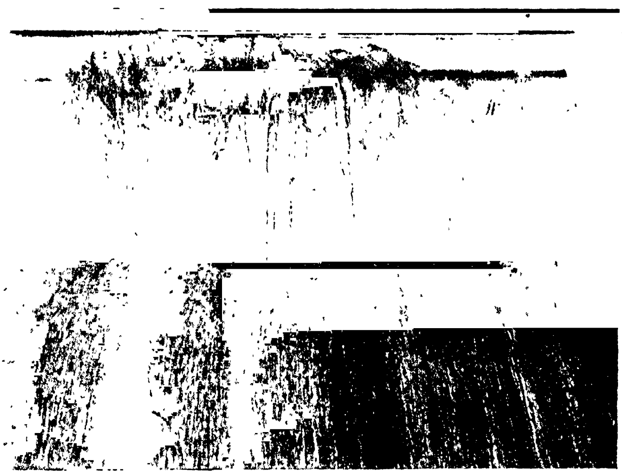

FIG. 145.

indeed, for some little time after. The heads of black jute were then fed into the machine in the ordinary way, and a black sliver emerged in a few seconds. When the last lot of black fibre had been deposited on the feed sheet, it was immediately followed by the heads of light-coloured jute. After the latter had passed into the card the machine was stopped, and the delivered sliver examined. The remaining fibrous mass amongst the pins of the cylinder was also examined. In both cases the result was exceedingly interesting and suggestive.

In the first place, it was found that, although all the black jute

had been fed into the card before the light-coloured jute entered, and that the machine ran for some little time after the delivery of the light sliver had commenced, a considerable amount of fibre was embedded at the roots of the pins, and that no inconsiderable quantity of this was black fibre. Moreover, much of this black fibre was amongst and partly underneath the light-coloured fibre. The appearance of the fibre on and amongst the pins of the cylinder is reproduced in Fig. 145, and even in this photograph some black fibres are apparent. In the second place, it was proved that, although the delivered sliver was absolutely black at first, as was perhaps to be expected, since no fibre of any other colour was being fed into the machine, it was accompanied by a gradually decreasing quantity of black fibre even after the light-coloured fibre emerged.

Fig. 146 illustrates five lengths of sliver which were separated for reproduction purposes; their positions in the length of the experimental sliver are indicated as under:—

A	= all black.					
B	= mixed sliver between		4th	and	5th	sections.
C	=	,,	8th	,,	9th	,,
D	=	,,	12th	,,	13th	,,
E	=	,,	32nd	,,	33rd	,,

A gradual diminution of the black fibre is quite marked in the complete length, while a rapid change is observed between some of the detached pieces in Fig. 146.

Until further experiments are conducted and more reliable information is gleaned with regard to the benefits or otherwise of the cushion of fibres at the roots of the pins, the most suitable lengths for pins will remain a debatable subject. It might, for example, be argued that the presence of such a cushion of fibres would offer a degree of resiliency to those fibres which are being split and combed, and even if certain fibres are pressed towards the wooden stave, they cannot very well leave this position without coming into contact with the pins of the various rollers, and receiving their share of treatment.

On the other hand, it might with equal justification be argued that the above-mentioned thick cushion of fibres is not essential, and that a thin layer is all that is required, if, indeed, any layer other than that which is being split and combed is desired at any

time. The main point to secure appears to be that no part of the fibrous mass shall be able to leave the cylinder and the other rollers until it has been satisfactorily carded.

Discussions bearing upon the length of the pins have taken place from time to time, and particularly with regard to the length of the pins in the cylinder. As a matter of fact, these discussions have been supplemented by the introduction of experimental coverings in which shorter pins than those in general use were

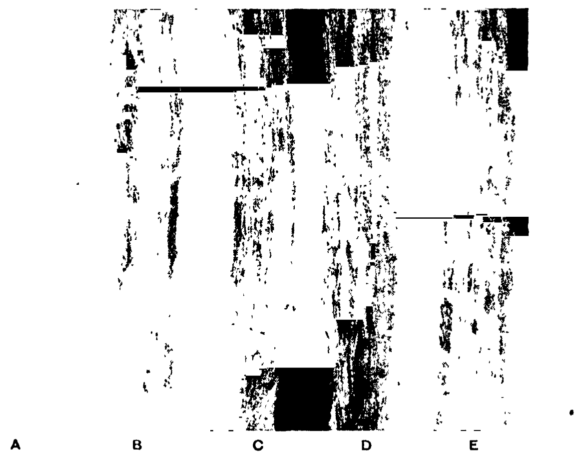

FIG. 146.

employed. In some of these trials the results have not come up to expectations, while in others it was acknowledged that a distinct improvement was apparent. It appears to us that the only way of deciding this important phase of the subject is to have two cards, clothed with experimental staves, working simultaneously on the same class and grade of fibre, and with the same gauging and speeds. The gauging and speeds in both cards could be altered from time to time, and in each case the resulting slivers could be compared. Moreover, the product from all these slivers could also be examined up to and in the yarn stage, and tests made with regard to strength

and other important requirements of the finished articles in yarn and cloth. Much information would result from such a series of experiments, and whether the information derived were positive or negative, the experiments would, we are sure, be well worth the trouble, time, and expense which would be involved.

If one could visualise the difference in the load of fibre on a stripper and the load on the other rollers, it would tend to more concentration on this phase of the subject. It is extremely interesting to examine the loads on the various rollers, and to consider the comparatively light loads which some of the rollers have to carry. Such an examination might possibly help to solve some of the difficulties which appear to surround this important preparing process. Fully convinced of the help which this information would give, we have calculated the average load on the pins of the various rollers of breaker and finisher cards, taking for our base a production of 56 cwt. in 10 hours, and slivers weighing 15 lb. per 100 yds. from the breaker card, and 10 lb. per 100 yds. from the finisher card.

With slight modifications of the speeds and other particulars supplied in the table on p. 140, and of such a nature that the calculations do not differ sensibly from the slight changes, we adopt the following particulars for the estimation of the various loads:—

BREAKER CARD.

No	Name of Roller.	Revolutions per Min	Approximate Diameter in Inches	Working Width in Inches	Surface Area in Sq. Ft.
1	Feed	4·5	10	66*	14·40
2	Cylinder . . .	190·0	49	66	70·55
3	Workers . . .	15·0	9	66	12·96
4	Strippers . . .	142·0	12	66	17·28
5	Doffer	25·5	15	66	21·60

* 5 ft. 6 in. working width for a 6-ft. roller.

Since we have fixed upon a weight of 56 cwt. per 10 hours—and this is an excessive production for one day from a breaker card with a sliver weighing 15 lb. per 100 yds.—it follows that we have—

$$56 \text{ cwt.} \times 112 \text{ lb.} = 6272 \text{ lb. in } 600 \text{ mins.};$$

or

$$\frac{6272 \text{ lb.}}{600 \text{ mins.}} = 10{\cdot}453 \text{ lb. per min. passing through the card.}$$

And since there are 7000 grains in 1 lb. avoirdupois, it is evident that there is an average of—

10·453 lb. × 7000 grains per pound = 73,171 grains of fibre passing over each roller per minute.

The number of square feet on the periphery of each roller is, of course, obtained as under :—

$$\frac{\text{Width of roller} \times \text{diameter} \times 3{\cdot}1416}{144 \text{ sq. in. per square foot}} = \text{square feet};$$

and the corresponding value of each roller is shown in the last column of the above table. If, therefore, we multiply the number of square feet on the periphery of each roller by the number of revolutions per minute of the roller, we shall obtain the number of square feet which pass a given point each minute; finally, if we divide the amount of fibrous mass by the speed in square feet per minute, we shall obtain the average weight of fibre on each square foot of the roller. Proceeding with this work for all the rollers, we find the results which are tabulated below :—

BREAKER CARD.

No.	Name of Roller.	Speed of Roller.	Surface Area in Sq. Ft.	Speed in Sq. Ft.	Delivery of Fibre in Grains.	Weight of Fibre per Sq. Ft. in Grains.
1	Feed . .	4·5	14·40	64·80	73,171	1129·00
2	Cylinder .	190·0	70·55	13,404·50	,,	5·46
3	Workers .	15·0	12·96	194·40	,,	376·40
4	Strippers .	142·0	17·28	2,453·76	,,	29·82
5	Doffer .	25·5	21·60	550·86	,,	132·80

With regard to the finished sliver from the finisher card, we propose to produce 28 cwt. per day of 10 hours, the sliver to weigh 10 lb. per 100 yds. Consequently we have—

28 cwt. × 112 lb. = 3136 lb. in 600 mins.;

or

$$\frac{3136 \text{ lb.}}{600 \text{ mins.}} = 5{\cdot}227 \text{ lb. per min. passing through the card.}$$

And bringing this weight of pounds into grains we obtain—

5·227 lb. × 7000 grains per pound
= 36,589 grains of fibre passing over each roller per minute.

As in the case of the breaker card, we supply the two tables, with particulars of the speeds, sizes, and areas of the various rollers in the first table, and the remaining particulars in the second table.

No.	Name of Roller	Revolutions per Min.	Approximate Diameter in Inches.	Working Width in Inches.	Surface Area in Sq. Ft.
1	Feed . . .	9·53	4	60	5·24
2	Cylinder . .	175·00	49	,,	64·14
3	Worker . . .	15·00	8·5	,,	11·13
4	Stripper . .	136·00	12	,,	15·71
5	Doffer . . .	20·17	15	,,	19·63

No.	Name of Roller.	Revs. per Min.	Surface Area in Sq. Ft.	Speed in Sq. Ft.	Delivery of Fibre in Grains.	Weight of Fibre per Sq. Ft. in Grains.
1	Feed . .	9·53	5·24	49·94	36,589	732·66
2	Cylinder .	175·00	64·14	11224·50	,,	3·26
3	Worker .	15·00	11·13	166·95	,,	219·19
4	Stripper .	136·00	15·71	2136·56	,,	17·13
5	Doffer .	20·17	19·63	395·94	,,	92·41

Working width taken at 60 in.

It will thus be seen that there is a very small weight even on what are considered loaded rollers such as the workers, while the weight per square foot on the cylinder is exceedingly light, and approximately equal to $\frac{1}{144}$th part of an ounce, and equal only to approximately $\frac{1}{68}$th part of the load on the worker. Again, the load on the worker is 14 times that of the load on the stripper.

Whatever interpretation is placed on the result of the foregoing calculations, it can safely be said that the pins are either too long for some of the rollers or too short for others, or else there is some purpose served relatively by the rollers the function of which is imperfectly known.

It has already been shown that the strippers are used for removing the carded fibres from the workers, and for returning them

to the pins of the cylinder. During this operation a very large amount of the impurities which are liberated in the process of carding drops out below the stripper; hence one would assume that these impurities would be ejected more easily when the stripper is clothed with short pins than when it is clothed with long pins. Again, the work of removing the fibres from the pins of the stripper will involve more difficulty as the length of the pins increases. It is well known that there is great difficulty in keeping the stripper roller clean when the machine is in work; consequently, if it were found that no loss of carded fibre resulted from shortening the pins, such a shortening would facilitate the operation of cleaning the stripper in the course of the ordinary operation of carding. This advantage is actually claimed by a firm of hacklemakers, and special coverings have been offered for finisher cards where this difficulty of cleaning the strippers exists; satisfactory results have attended those cards which have been clothed in this way.

The shortening of the pins should be accompanied by a change in the angle of the centre of the pin—that is, in the drilling of the stave; the angle of the face of the shorter pin should be at least as acute as that of the face of the longer pin, provided that the angle of the latter had been found to be the most efficient angle of the pins for the work. Up to the present, however, no definite angle has been fixed, although all the pins for similar rollers in various cards are inclined to the roller at angles which differ little from each other. Thus the angle which the centre of the pins in the stripper makes with the tangent to the roller is approximately 40°, as shown in Fig. 84, and we might take this as a normal inclination.

In Fig. 147 the periphery of the wooden staves of a stripper is represented by the circle A; B C is a vertical line through the centre O, and D E is the tangent to the circle at point F. A line G H passing through the point F and inclined at 40° to the tangent D E will represent the direction of the centre of the pin P, greatly exaggerated in this figure; the line G H hence decides the radius of the tangent circle J.

A much enlarged view of the pin P is reproduced in Fig. 148, the centre line F H being again inclined to the horizontal F E at 40°. Now it is quite evident that the line K L in Fig. 148, which

represents the line of the face of the pin P, forms an angle L K M which is greater than the angle H F E formed by the centre line of the pin with the horizontal. And while the latter angle would remain constant for all diameters of pins, the former would change with every alteration in diameter, provided that the length of the pin remained constant. If, however, the length of the pin be shortened, and its diameter correspondingly decreased, as exemplified by the smaller dotted pin in Fig. 148, the angle of the face of the pin would remain constant for all changes. A decrease in the length of the pin means a decrease in its resiliency, whether the

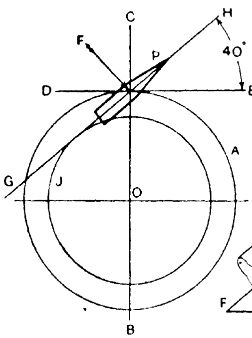

FIG. 147.

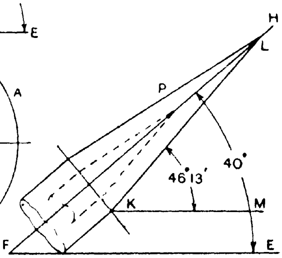

FIG. 148.

latter property is desired or not, and therefore an increase in its power or in its resistance to bending or breaking. Hence a similar strength of pin may obtain with a decreased length, but it does not follow that this proportionate decrease would either meet with the approval of those engaged in the trade, or fulfil satisfactorily the functions which the pins have to perform.

We shall assume, therefore, that for some reason it is desired to decrease the length of the projecting part of the pin by one-half, from $\frac{5}{16}$ in. to $\frac{5}{32}$ in., but that the same diameter of pin shall remain. The problem is practically equivalent to rotating the half-length pin, shown in dotted lines in Fig. 149, to the position shown in heavy lines, in which position the face of the short pin is parallel to the face of the long pin, and both pins are the same in diameter.

The pins for the stripper are made from steel of No. 15 W.G., the diameter of which is 0·072 in. A further enlarged view of the tapered part of the longer pin appears in Fig. 150, in which F L represents $\frac{5}{16}$ in., or 0·3125 in.

(151) $$FK = \frac{0·072}{2} = 0·036 \text{ in.}$$

and

(152) $$\frac{LF}{FK} \text{ or } \frac{0·3125}{0·036} = 8·6806.$$

(153) $$\therefore \quad \tan FKL = 8·6806;$$

whence angle F K L = 83° 27′ approx., and therefore angle F L K = 6° 33′. The dotted line K N is parallel to the line F L, and there-

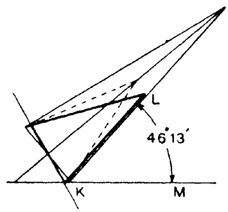

FIG. 149.

fore the angle L K N is equal to the angle F L K = 6° 33′; and since both lines F L and K N are inclined at 40° to the horizontal, it follows that the angle L K M formed by the face of the pin with the horizontal is—

(154) $$40° + 6° 33' = 46° 33'$$

—that is, the angle between the face of the pin P, Fig. 147, and the tangent D E is 46° 33′.

Now, the length of the shorter pin is to be $\frac{5}{32}$ in., or 0·15625 in., and the radius of the pin is still 0·036 in. Hence, in Fig. 151, the tangent of the angle $fkl = \frac{0·15625}{0·036} = 4.3403$, whence the angle $fkl = 77°$ approx.; and therefore angle $flk = 13°$. Consequently, the centre line of the shorter pin should be inclined to the horizontal km at—

(155) $$46° 33' - 13° = 33° 33',$$

and of course inclined at the same angle 33° 33′ to the tangent D E in Fig. 147.

In the smaller diagram in Fig. 151 the face $l\,k$ of the pin is at the same angle as the face L K of the larger pin in Fig. 150, but the centre line $f\,l$ in Fig. 151 is drawn, not at 40°, but at 33° 33′.

The centre lines of the two pins are shown in Fig. 152 touching the respective tangent circles; thus J represents the tangent circle for the long pin, while j represents the tangent circle for the short pin. The principle can, of course, be applied to any length of pin and any diameter, and for any roller, provided that the angle which

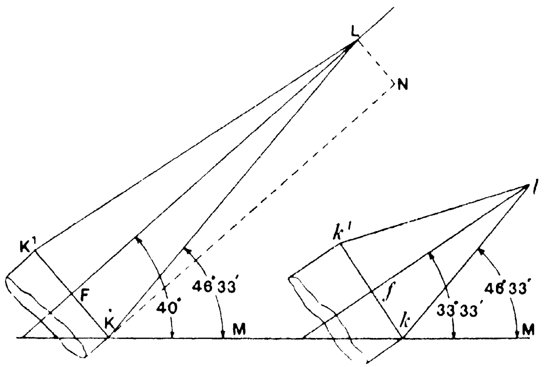

FIG. 150. FIG. 151.

the face of the pin makes with the tangent D E is fully decided upon.

It might be stated that the above-mentioned firm of hackle-makers have urged the use of shorter pins as constituting an advantage, and such pins have been adopted with good results by most spinners engaged with flax tow. It might be argued that there are great differences between the fibres of flax and jute; but whilst admitting this in the main, it can be said with truth that the actions involved in the carding of the two kinds of fibres are very similar.

These simple experiments and calculations may suggest that the whole system of carding might be investigated with the object

of confirming or disproving the claims, and also of placing the operations of carding on a more secure basis than that which exists at present.

The removal of impurities in the form of dust and the like from the air in the various departments of a jute mill is not only desirable from a hygienic point of view, but is now imperative, and the selection of a suitable plant for this purpose is at present possible owing to the varied experience and knowledge of many of those engaged in the manufacture of such equipment. In some of the well-designed buildings it has been found possible to collect all the dust (which would otherwise give trouble in subsequent opera-

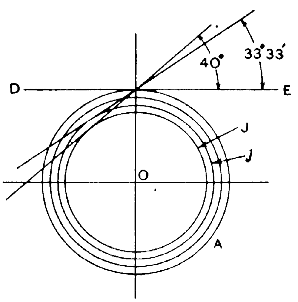

FIG. 152.

tions) from the jute in the batching department, provided that the installation is fitted up for fulfilling satisfactorily the functions mentioned below.

A dust-extracting plant which has been erected in some of the mills, and which has given excellent results, is that made by Messrs. J. M. Adam & Co., Glasgow. The apparatus is designed on scientific principles with a view to a minimum consumption of power and a maximum efficiency, and the structure forms a very complete and high-class equipment for the purpose. The objects aimed at, and apparently achieved, are :—

1. To collect the dust at the point of generation—*i. e.*, where the dust is most likely to leave the fibre.
2. To continue and augment the natural direction of motion

of the dust-laden air so as to prevent the deposition of the dust in the room.

3. To construct the air-ducts so that an accelerated movement is imparted to the air as the latter is drawn through them,

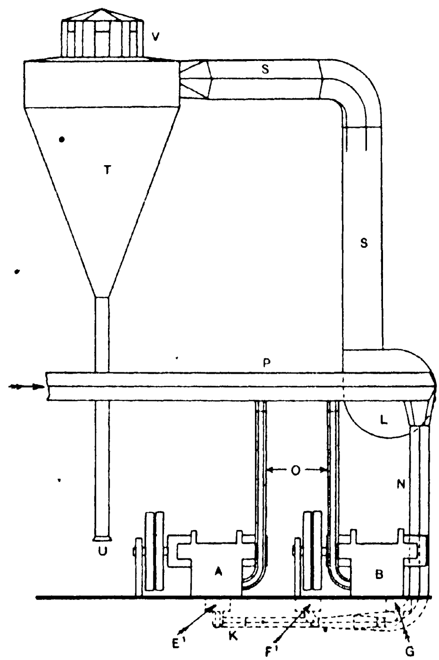

FIG. 153.

and with no possibility of the air currents allowing the dust to drop on its journey towards the fan.

4. To provide an efficient separating plant whereby the dust may be collected in a chamber and the pure air set free.

Figs. 153 and 154 show, in elevation and in plan, part of an apparatus which has been installed for use in connection with a bale-opener and two softening machines. A and B represent

diagrammatically two softening machines, while the bale opener, shown only in Fig. 154, is indicated by the letter C. The jute

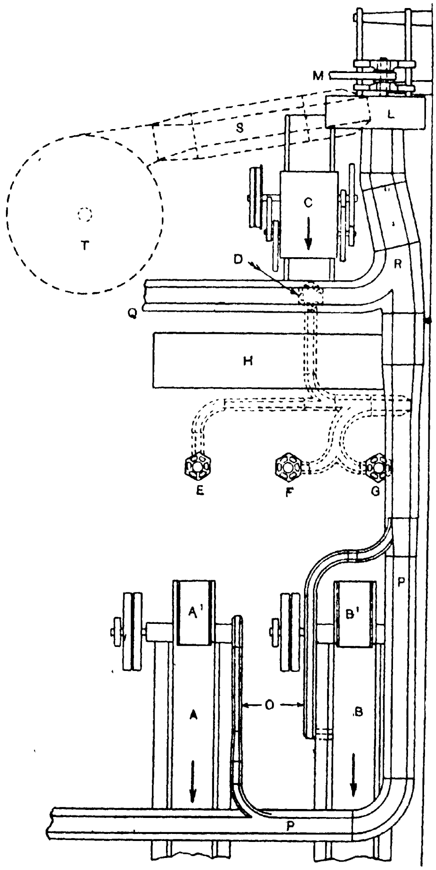

Fig. 154.

passes through the bale opener C in the direction of the arrow, and near the point of its delivery is a grate D. Three other grates, E, F, and G, are situated between the breaking-up or striking-up

bench H and the feed sheets A^1 and B^1 of the two softening machines through which the fibre passes as indicated by the arrows. The stillage or stalls where the stricks are built are not illustrated in these figures. The above grates fit over the openings of pits E^1, F^1, and G^1, Fig. 153. Each complete pit, constructed as illustrated in plan and sectional elevation in Fig. 155, forms a "patent fibre retarding pit."

The method of manipulating the heads of jute tends to cause the dust to move downwards, but in the absence of an effective dust-withdrawing apparatus the swish of the stricks spreads the dust in

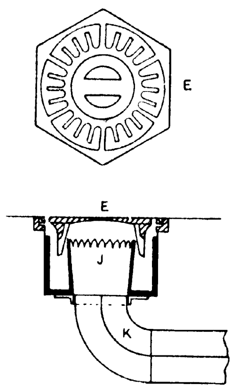

FIG. 155.

all directions. The above apparatus is designed to create conditions which will continue the downward movement of the dust, and suck in the dust-laden air through the grates which are placed on the floor level and in suitable positions with regard to the operatives. A steady and continuous fall of the vitiated atmosphere, which usually reaches a height of about five feet from the floor, obtains, and fresh air is thus drawn from above to replace the volume absorbed by the apparatus.

The upper opening J of the pipe K, Fig. 155, is constructed as illustrated, and, while most of the dust passes through the pipe K, the fibres are retained by the pipe and the patent tentacle form of

grating, and may be disentangled without cutting. The grates may easily be lifted to clean out the pits.

Adam's patent fan is located at the place marked L, Figs. 153 and 154. It is driven by a belt M to induce air currents, so that the dust from the pits may pass along the pipes K, Fig. 153, and up the pipe N. Similar pipes, O, serve to conduct the dust—which is drawn from under the machines—to the larger pipe P. Dust from other machines on the left also passes through the pipe P, while a further pipe Q, Fig. 154, from a further set of machines, joins pipe P at R. All the dust-laden air is then forced through the pressure pipe S, Figs. 153 and 154, and delivered into a separator T, which is housed in a framed steel gantry near the roof of the building. A bag is placed at the mouth of the dust pipe U to collect the dust, while the air is caused to escape at the upper end part V, Fig. 154, of the separator.

Such an apparatus not only creates a comparatively clear atmosphere for the operatives, but prevents the dust from being scattered all over the batching department; moreover, a considerable quantity would, if not withdrawn, settle on the treated jute, and would pass with it to the breaker cards, only to be re-scattered in the card-room.

In some cases a plant for dust extraction is installed in the card room, or even at individual machines, and occasionally in rooms where subsequent operations are conducted. It is unnecessary, however, to duplicate the description and illustrations, although the apparatus may be referred to again in Part II of this work, which will deal with the operations of drawing, roving, spinning, twisting, reeling, winding, and chain warping.

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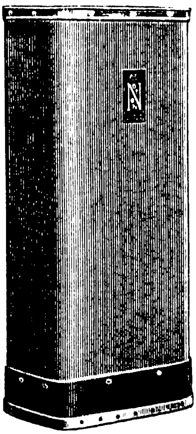

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